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MONTHLY WEATHER REVIEW

MARCH, 1929

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CORRECTION

MONTHLY WEATHER REVIEW SUPPLEMENT No. 30 (Forest and Streamflow Experiment at Wagon Wheel Gap, Colo.), page 75, Table 66, the precipitation entries of 0.94 and 0.82 for April 21, 1919, at Stations A and B should be deleted.

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

VOL. 57, No. 3
W. B. No. 981

MARCH, 1929

CLOSED MAY 3, 1929
ISSUED MAY 27, 1929

THE CLIMATIC RECORD OF HONDURAS

By NELS A. BENGTSON, PH. D., Professor of Geography

[The University of Nebraska, Lincoln, Nebr.]

Seasonal atmospheric pressure.—In January, Honduras lies along the northern edge of the equatorial low-pressure belt. High pressure reaches then its maximum development over much of North America, while low pressure is at its climax south of Central America. This of course gives rise to highly-developed trade winds which are dominant over the entire country, the winds being generally from a northeasterly direction.

In July, Honduras is in the midst of a low-pressure trough with a barometric pressure of about 29.9 inches while centrums of high pressure reach 30.2 inches in the Atlantic to the northeast and in the Pacific to the south and southwest. This produces a season of variable winds, in general on-shore along both coasts and strongly convectional in the interior and of course with significant relation to rainfall conditions.

Seasonal wind conditions.—Along the north coast the northeast trades are prevalent throughout the year but vary locally in intensity and direction, and seasonally as they are modified by adjacent conditions. During the winter they prevail over the whole country, even reaching the Pacific as dry offshore winds. In the summer months, however, a monsoon situation prevails so that the northeast trades reach a warm, low-pressure interior which induces the characteristic ascending convectional air motion.

The south coast has prevalent northeast winds from October to March and prevalent southwest winds from April to September. These opposing wind directions do not of course attain full development except at the midperiod in which each holds sway. The shift lasts from four to six weeks during which period variables prevail.

The interior is dominated by local breezes except during the season of the trades. During the period from April to September the winds are variable, being induced by unequal heating of the various slopes and inclosed valleys of a rugged landscape, as well as by the varying strengths of the opposing north coast and south coast breezes. The results are reflected in great variability of winds and rainfall and, to a lesser extent, of temperature.

Temperature conditions on the Caribbean coastal plain.—Early accounts of the temperatures along the north coast of Honduras emphasized the relations of health and well-being but failed to give exact data. There is convincing evidence that the aborigines of pre-Mayan and Mayan times considered the lowlands undesirable places in which to live. Until recently, the north coast was referred to by the native Indians as a fever zone, or even as "a zone of death."

Since 1920, temperature records have been kept by the fruit companies at a number of stations, and these records indicate that the prevalent temperatures are not very high and that in themselves they should not be held accountable for many of the discomforts commonly attributed to them.

The temperatures characteristic of the Caribbean coastal plain are typified by the data for the areas near Tela and Trujillo comprising the middle one-half of the north coast belt. During the 3-year period, 1924–1926, the lowest temperature recorded at the Maloa station of the United Fruit Co. was 62° F. (March, 1925) and the highest was 97° F. (May, 1925). At Black River station the lowest for the same period was 67° F. (February, 1924) and the highest, 99° F. (May, 1925).

The temperatures shown for the Trujillo division are the composites of the readings at several stations from Trujillo to Iriona and represent, as fairly as is possible for a short-period record, the temperatures prevalent along the northeast lowlands of Honduras. The mean annual temperature for the period, 1924–1926, was 80.8° F. February, with an average temperature of 75.7°, was the coldest month, while September, with an average of 83.3°, was the warmest.

TABLE 1.—*Caribbean coastal plain temperatures*

[In ° F.]

TRUJILLO DIVISION, HONDURAS

Month	1924		1925		1926		Monthly mean
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	
January	84	69	88	71	86	69	77.8
February	84	67	88	67	86	68	75.7
March	91	69	89	65	88	68	78.3
April	94	71	92	70	93	71	81.8
May	96	74	92	72	90	73	82.8
June	93	73	94	75	89	75	83.1
July	89	71	89	71	89	74	80.5
August	92	73	92	73	91	73	82.3
September	95	74	94	74	89	74	83.3
October	90	72	91	73	86	75	81.1
November	82	71	89	72	83	72	77.0
December	84	71	89	70	84	73	78.5
Annual mean	90	72	90	71	88	72	80.8

The records for the 4-year period 1923–1926 give a mean annual temperature of 78.4°. The results are virtually the same in the two areas, because differences in tabulating the readings are sufficient to account for the slight differences in the final figures.

Humidity on the Caribbean coastal plain.—As far as human well-being is concerned, humidity is nearly as important as temperature. The average relative humidity reported by stations in the Tela district for the 3-year period, 1924–1926, was 86 per cent and by the stations in the Trujillo district for the same period it was 83 per cent. The readings were taken rather early each morning when

the air was cool, hence the humidity recorded was probably higher than would have been the case if readings had been made nearer the noon hour. Yet the fact remains that humidity is high all along the north coast lowlands and is responsible for much of the enervating effect of the climate upon white residents in that section. Temperatures averaging around 80° with an average humidity of about 80 to 85 per cent make a combination which is a radical departure from Temperate Zone conditions, and one which must be taken into account by all who plan to develop industrial enterprises in that area.

TABLE 2.—*Relative humidity (in percentages)—The Carribean coastal plain of Honduras*

TELA DIVISION

Month	1924			1925			1926		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
January	95	67	85.3	91	81	85	79	62	73
February	96	72	88	87	82	84	(1)	(1)	(1)
March	92	73	83.4	87	82	84	87	70	75
April	89	74	82	87	80	83	88	72	85
May	85	75	80	90	80	83	96	69	73
June	85	70	80	91	80	85	96	56	78
July	83	76	82	86	81	83	96	88	93
August	86	77	82	91	82	89	91	76	84
September	86	79	82	87	81	84	91	79	85
October	87	80	83	86	80	83	91	83	86
November	92	83	88	84	72	82	95	78	84
December	90	84	87	92	80	86	95	82	86
Extremes and means	96	67	83.5	92	72	84	96	62	------

[1] No record.

TABLE 3.—*Relative humidity—The Caribbean coastal plain of Honduras*

TRUJILLO DIVISION

Month	1924			1925			1926		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
January	92	81	86	92	80	86	91	77	86
February	92	66	86	91	78	86	96	81	89
March	93	65	80	88	72	82	91	73	83
April	86	74	82	86	72	81	90	77	81
May	86	70	80	87	74	80	86	74	80
June	89	74	82	91	77	84	84	74	79
July	94	77	84	87	76	81	83	73	81
August	87	77	82	89	81	84	89	77	82
September	83	73	79	90	78	84	86	71	78
October	89	74	81	88	77	85	89	68	82
November	92	77	85	94	81	85	95	73	86
December	93	83	87	94	80	79	93	76	82
Annual	93	65	83	94	72	83	96	68	82

Temperatures in the interior highlands.—The only early temperature records available for interior Honduras are those which were kept at Tegucigalpa by Dr. R. Fritzgartner in 1888 and 1889 and published by him in the weekly periodical, Honduras-Progress, for those years. For the 2-year period as published, the average annual temperature was 72°, the average maximum temperature was 81°, and the average minimum temperature was 64°. May was the warmest month with an average temperature of 76.2°, and December the coldest month, temperature 66.1°.

TABLE 4.—*Average monthly temperatures at Tegucigalpa*

[1888 (°F.)]

January	68.01	May	72.88	September	73.51
February	70.78	June	74.98	October	71.86
March	73.38	July	73.88	November	71.13
April	74.42	August	72.88	December	66.10

Average maximum temperature=80.57°.
Average minimum temperature=63.95°.
Average annual temperature=72.26°.

TABLE 5.—*Range of temperature at Tegucigalpa, 1888–89*

[°F.]

	January	February	March	April	May	June	July	August	September	October	November	December	Extreme
Lowest temperature	51	52	55	56	61	63	62	62	61	61	59	50	50
Highest temperature	82	88	88	90	90	86	84	84	85	87	82	81	90
Extreme range	31	36	33	34	29	23	22	22	24	26	23	31	40

The record for Tegucigalpa is considered to be fairly representative for interior locations of about 3,000 feet altitude. It is quite clear that December to February is the coldest period and that the warmest period lasts from April to early June. The reasons for this seasonal distribution of temperature are chiefly twofold, viz, the cold period is a response to the low altitude of the sun at that season and the influence of the northern winter extending, though faintly, into Central America; the warm period is the result of the zenith position of the sun, together with relatively clear skies and a dry terrain. As the rainy season advances, cloudiness increases, insolation upon the land surface decreases, evaporation is accentuated by the greater abundance of available moisture, and lower temperatures result.

Local differences in temperature are great, induced by differences in altitude, exposures on different slopes, and differences in humidity conditions. On some of the interior, mountain-inclosed basins where during much of the year desert conditions prevail, the maximum temperatures not infrequently exceed 100°. Along the lower slopes north of the San Juancito Range, maximum temperatures of 110° have been reported. In the San Juancito Mountains at about 6,000 feet, the maximum temperature reported is 85° and the minimum is 38°.

The office and camp of the New York and Honduras Rosario Mining Co. are located on the east slope of the San Juancito Mountains at an altitude of 5,000 feet. The mountains rise about 2,500 feet higher, while eastward the slopes are precipitous to the valley floor which lies at a little less than 3,000 feet. The warmest months as reported from the records at the camp, are those of the dry period, March to June. During that season the temperature range is from a minimum of about 58° to a maximum of 80°, although occasionally 85° is reached. From June to November slightly lower temperatures prevail but the difference is not marked. From November to March a noticeable decrease is experienced, the average minimum temperatures being 50°–55°, and on rare occasions dropping as low as 46°. During that season the average maximum is around 70°.

Records for higher altitudes are wanting. Some of the natives claim that light snow flurries have occurred on the summits of the San Juancito and Selaque Mountains but the truth of these statements is open to question.

Temperatures on the Pacific coastal plains.—No reliable records of temperature are known for the Pacific coastal plain of Honduras. It is generally recognized that the temperatures are similar to those of the north coast, but that the humidity is much lower and the alternation of land and sea breezes is more pronounced, thus giving rise to pleasant and bracing weather conditions.

AMOUNT AND DISTRIBUTION OF RAINFALL

General considerations.—A general summary of the rainfall situation of Honduras gives the contrasting conditions which prevail in the three principal physiographic regions. Along the south coast the dry season lasts from December to March, inclusive. The season is truly dry for in many years no rain whatever falls during

this period. Winds are dominantly from the northeast, brilliant sunshine is the rule, and the weather as a whole is agreeable and stimulating. This is the *Verano* season, a period of such dryness that it becomes a common rest period for most vegetation. Deciduous trees shed their leaves, giving the landscape toward the close of the season almost a desert-like appearance. Then follows the rainy season, the *Invierno*, quickening vegetation into life almost as by magic, and reaching its culmination in June. Several weeks of less rain then ensue, giving rise to a short, drier season known as the *Veranillo*, after which heavier rains again set in and then gradually taper off until November when the real dry season, the *Verano*, begins.

In the interior highlands the rainfall varies with altitude. At altitudes below 4,000 feet but little rain falls from December to March, nevertheless, the season is not without some rain. At the higher altitudes, especially above 6,000 feet, showers are frequent even during this season. April usually marks the beginning of the rainy season, June its climax, and November its tapering off into the *Verano*, or major dry season. Some of the inclosed basins receive rain only during the height of the rainy season, and are almost rainless for from six to eight months of the year. On the other hand, the highest mountain summits are bathed in showers of varying intensities the year round which lead to vegetation caps of jungle type. Great local variations within short distances, either horizontally or vertically, are characteristic of the interior.

In the area of the Caribbean coastal plain heavy rainfall and high humidity are typical. Some rain falls every month, but March marks the middle of a 3-month period of slight precipitation, while the climaxes of the rainy season occur in the height of the summer and in November. The *Veranillo* usually occurs in September or October but merely marks a period when the rains are less than during the preceding and succeeding weeks. November is the month of maximum rainfall over this region, followed by a very sharp decline in December.

During recent years the large American fruit companies operating in the Caribbean area have begun to keep daily rainfall records, a practice which eventually will furnish a safe basis for deductions regarding causal and distributional relations. Except for a few places such records were not begun until 1923 and 1924, hence at present only short-term records are available for much of the area. In the interior and along the south coast, detailed records are lacking, and so only brief and incomplete analyses of conditions can be made for those regions.

Rainfall of the Pacific coastal plain.—The only known detailed record for this region is a series of observations made by Mr. J. E. Foster of Nacaome [1] for the years 1910 to 1915, given herewith:

TABLE 6.—*Rainfall record at Nacaome, Honduras*

[Inches]

Month	1910	1911	1912	1913	1914	1915	Average
April	1.0	0.2	0.0	3.0	6.5	0.3	1.83
May	7.5	14.6	2.3	14.6	1.5	9.7	8.37
June	11.3	13.6	14.5	20.3	7.7	15.0	13.73
July	9.9	2.0	2.8	2.4	1.0	3.7	3.63
August	7.3	6.5	4.8	9.4	.3	(a)	5.66
September	13.0	6.8	3.7	20.2	3.4	(a)	9.42
October	5.3	3.2	8.5	11.3	4.4	(a)	6.54
November	1.0	8.1	2.0	.0	4.8	(a)	3.18
Total	56.3	55.0	38.6	81.2	29.6	----	51.36

a No record.

[1] Foster, J. E.: "Observaciones sobre las Estaciones" Boletin de la Secretaria de Fomento, Obras Publicas, y Agricultura, vol. 5, p. 45. Tegucigalpa, January–March, 1916.

In the report concerning the rainfall during the years given, the dates of the earliest and the latest rains of each season were stated to be as follows:

Year	Date of first rains	Date of last rains	Remarks
1910	Apr. 16 and 17	Nov. 14 to 16	Only a few light showers in April.
1911	May 9	Nov. 20 to 21	
1912	May 14	Nov. 15	
1913	Apr. 12	Oct. 29	
1914	Apr. 29 to 30	Nov. 10	
1915	May 10	----	Scattered, light showers before May 10.

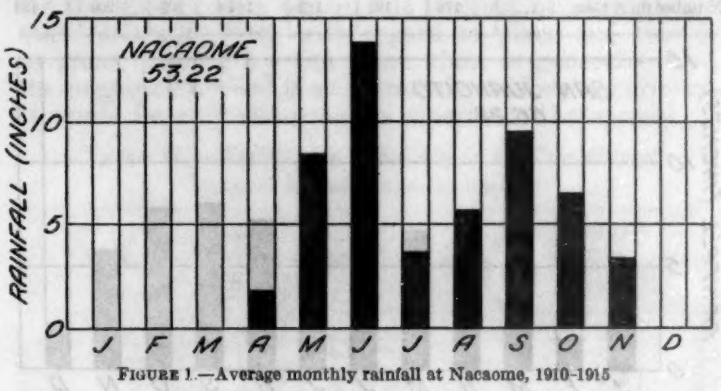

FIGURE 1.—Average monthly rainfall at Nacaome, 1910-1915

The preceding tables illustrate clearly the significance of the double movement across Honduras of the equatorial low-pressure belt and the lag of the maximum rainfall periods attending it. On the Pacific coast the *invierno* alone produces rain but is interrupted during July and August by the short season of lessened rain known there as the *Veranillo de San Juan*. This rainfall distribution is typical of the Pacific coast of Central America as far as southern Costa Rica. The principal causes of the rains appear to be the ascending air movement of the equatorial low-pressure variables augmented by the monsoon trades from the southwest.

Rainfall in the interior highlands.—The only carefully kept rainfall record known for interior Honduras is one for San Juancito reported by the New York and Honduras Rosario Mining Co. (Table 7). The gauge was presumably located near the headquarter's offices of the company at an altitude of about 5,000 feet. The record was begun in 1913 and since it has been kept consistently since that time, it has become one of sufficient duration to give it high value. The monthly rainfall, 1913–1926 is presented in the following tables and the means are graphically shown in Figure 2.

TABLE 7.—*Rainfall record at San Juancito, Honduras*

[In inches. Station at 5,000 feet altitude, facing northeast]

Month	1913	1914	1915	1916	1917	1918	1919
January	3.15	0.92	0.83	2.76	2.04	0.81	0.64
February	0.88	1.52	0.72	1.10	0.55	2.40	2.81
March	1.46	1.20	5.87	1.46	0.24	0.72	0.07
April	4.80	2.64	2.51	2.60	0.56	3.70	0.72
May	9.74	3.45	4.86	8.82	2.57	5.86	8.64
June	13.37	7.07	14.49	9.97	11.31	14.89	6.87
July	8.19	3.75	7.22	12.64	10.51	6.04	6.20
August	5.74	2.27	5.94	15.52	10.92	4.16	7.87
September	10.67	5.81	7.97	8.23	15.69	11.71	13.58
October	10.31	5.72	6.76	8.47	16.28	11.45	5.16
November	4.35	3.98	13.17	4.33	0.91	6.11	2.64
December	1.89	2.22	1.72	1.83	2.70	4.26	2.24
Total	74.55	40.55	72.06	77.73	74.28	72.11	57.44
Number days rain	168	150	172	169	159	188	184

TABLE 7.—*Rainfall record at San Juancito, Honduras*—Contd.

Month	1920	1921	1922	1923	1924	1925	1926
January	2.24	3.43	1.45	2.22	2.29	2.27	1.00
February	0.80	0.86	1.49	0.19	2.17	0.30	0.57
March	1.52	0.97	1.24	0.29	0.19	0.58	0.09
April	0.03	0.25	0.16	0.38	2.49	4.87	0.09
May	14.32	9.01	10.46	7.34	3.47	7.72	2.33
June	16.19	15.59	11.08	13.24	7.98	7.92	4.35
July	4.27	6.98	3.57	5.23	8.96	5.47	5.88
August	8.00	5.88	7.86	5.93	8.42	4.95	9.02
September	7.49	11.82	8.28	5.48	11.25	11.15	10.69
October	8.58	12.56	8.19	2.02	13.79	4.12	10.56
November	5.91	1.97	3.11	2.63	1.86	4.40	2.42
December	1.83	1.50	2.46	2.17	3.60	1.86	1.78
Total	71.18	70.82	59.35	47.12	66.47	55.61	48.78
Number days rain	179	193	153	164	203	200	134

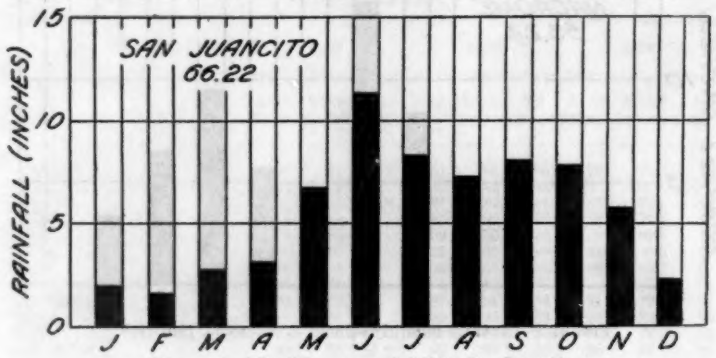

FIGURE 2.—Monthly mean rainfall for San Juancito

The mean annual rainfall for the period was 63.46 inches, and the average number of days per year when rain fell was 172.

This record shows clearly the summer rainy season which is characteristic of the interior highlands. The mean maximum occurs in June; this is followed by a poorly defined *veranillo* during July and August and that by a second, weaker maximum in September. December to April is the dry season, the *verano*, a period during which little rain falls at altitudes below 4,000 feet.

The *verano* ends in April. Toward its close the weather is the hottest of the year, the skies are clear, the sunshine brilliant. On the plateaus and higher mountain slopes the season is delightful, its charm broken to some extent however by the pall of smoke which hangs over the landscape. This is due to the fires set to the dry grass by the natives in order to reduce the numbers of ticks, the *garapatas*, which are then veritable pests for both man and beast.

Rainfall on the Caribbean coastal plain.—Rainfall records for relatively long periods are available for but three stations along the Caribbean coastal plain, viz, Cuyamel, Tela, and Trujillo. These stations are, however, so situated as to give a fairly representative section of the north coast area. Records for shorter terms are available for a number of places, and beginning with 1923 and 1924 rainfall data are being recorded at a great number of stations by the various fruit companies. In the course of a few more years data for safe deductions as to amount, distribution, and variability of rainfall in this area will thus become available.

TABLE 8.—*Rainfall record for the north coast of Honduras*

Station	Length of record	Average annual rainfall
	Years	*Inches*
Cuyamel	14	124.81
Tela	12	96.67
Trujillo	12	71.00

The rainfall is less than is ordinarily supposed to be the case. The general average annual rainfall for the three stations quoted is only 97.49 inches. Furthermore, the western part of the north coast evidently has greater rainfall than does the eastern, a situation quite in contrast to the prevalent impression held in many quarters that the northeast lowlands are literally drenched in rain. The heavier rainfall westward along the coast is accounted for by the configuration of the coast line of that section of the Bay of Honduras and the rugged terrain which rises abruptly back of the coast there. The moisture-laden northeast winds virtually converge in the vicinity of the Gulf of Amatique, Guatemala, and are forced to rise over the highland barrier, thus setting up a series of currents which result in heavy precipitation within the adjacent area. In northeastern Honduras the mountains are farther from the coast and the rainfall is therefore less concentrated on the coastal lowlands.

Seasonal distribution of rainfall along the Caribbean coast.—The percentage of the total annual rainfall which falls in each month appears to be relatively the same for the various stations along the north coast area. The dry season occurs during March, April, and May, while the remaining nine months of the year may well be called the rainy season. A well defined maximum occurs in November which in some cases accounts for 25 to 30 per cent of the year's rainfall. Late August or September is expected to bring some let-up in the rains but ordinarily the veranillo does not reach as pronounced development as it does in the south coast area or in the interior.

The record of rainfall at Tela dates back to 1914 and has been kept so faithfully that it is now one of the most valuable in Central America. The mean annual rainfall during the period 1914 to 1926 was 96.67 inches. One of the most striking characteristics brought out by this record is that of variability in annual and in monthly rainfall. During the 13-year period the total annual amounts ranged from 52.21 inches to 128.71 inches. The rainfall in 1924 was *62.42 inches greater than that of the preceding year.*

TABLE 9.—*Rainfall record at Tela, Honduras*

[Inches]

Month	1914	1915	1916	1917	1918	1919	1920
January	8.59	5.65	4.69	3.21	9.10	11.26	12.47
February	4.17	6.87	6.17	8.01	6.22	6.51	3.45
March	13.66	12.41	6.52	7.25	.70	1.52	9.72
April	3.03	4.82	4.13	.77	5.07	6.52	3.31
May	3.30	2.33	4.75	5.32	3.80	.50	3.20
June	3.30	5.46	2.37	7.88	11.03	8.96	3.28
July	3.04	4.02	2.69	5.35	9.71	8.65	6.89
August	5.39	13.07	3.85	9.12	13.38	9.92	5.08
September	5.91	10.07	10.53	5.27	8.65	20.78	8.16
October	9.36	26.61	13.67	11.41	10.67	12.73	6.98
November	20.25	15.55	21.73	33.47	19.79	5.88	12.83
December	4.95	18.06	6.03	11.36	23.94	29.26	8.47
Total	84.95	124.92	87.14	108.42	122.06	122.49	83.84

Month	1921	1922	1923	1924	1925	1926	Average
January	13.50	5.38	6.74	12.45	5.35	21.57	8.46
February	3.51	7.23	1.76	16.25	3.36	9.17	6.38
March	2.99	2.24	.26	2.93	.91	4.35	5.47
April	1.92	.45	.23	.68	2.02	2.69	2.81
May	2.35	1.23	1.40	2.47	4.82	8.45	2.73
June	8.69	4.79	4.92	4.80	7.86	.66	5.95
July	5.88	4.93	4.80	8.49	4.72	8.81	5.86
August	5.47	8.14	4.83	7.79	10.43	7.24	7.82
September	8.37	6.54	5.53	7.11	11.31	3.88	8.81
October	6.40	11.22	8.44	7.09	3.32	13.93	11.32
November	8.03	3.92	8.95	33.44	21.83	31.46	16.71
December	8.23	9.38	4.35	11.13	8.77	16.49	12.29
Total	75.34	65.45	52.21	114.63	84.70	128.71	94.68

Much misconception exists regarding the rainfall situation on the Caribbean coastal plain. It is commonly supposed that the rains are almost constant during the wet season and that even the dry season is characterized by rains almost daily. The popular expression, carelessly bandied about, "during the wet season it rains all the time and during the dry season, every day," summarizes the popular fallacy. It is therefore well to emphasize that even the Caribbean coast of Honduras, with an average annual rainfall in the neighborhood of 100 inches, has a remarkably high percentage of rainless days. More than 60 per cent of the days are rainless, and even on the days when rain does fall the skies are clear and the sun shines brilliantly much of the time.

The Tela district has a central location and hence is considered to be fairly representative of the north coast conditions. Monthly summaries of the records of five stations in this district for the period 1924–1926 are presented in Table 10. The average number of days with rain was only 138.4. Even November, the rainiest month, had only 19 days when some rain fell, and April averaged less than 3 rainy days for the district as a whole.

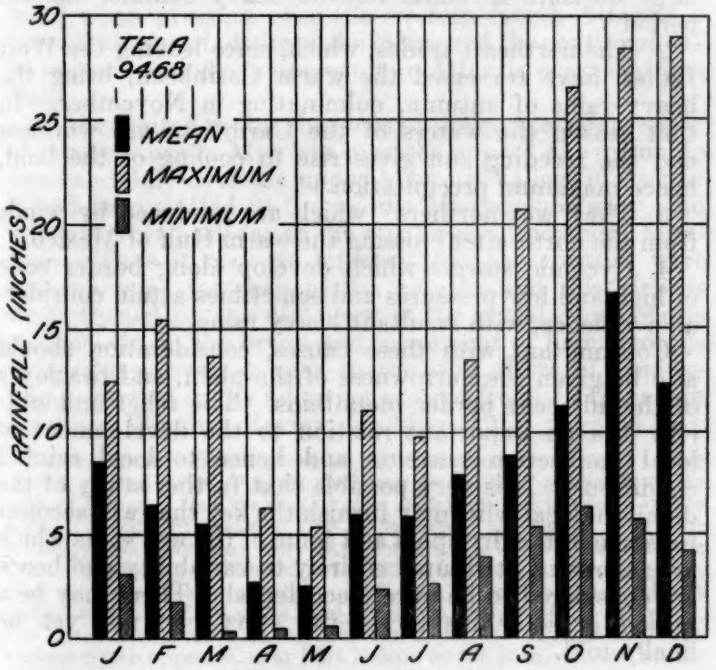

FIGURE 3.—Monthly mean, maximum, and minimum rainfall, Tela, 1914–1926

TABLE 10.—*Rainy days in the Tela District*

[Average, 1924–1926]

Month	Uluasito	Dakota	Tela	Farm 10	Progresso	District average
January	14.0	11.0	13.6	8.0	7.3	10.78
February	12.3	9.0	11.0	7.3	9.0	9.72
March	7.0	5.0	4.3	2.3	3.3	4.38
April	4.7	3.0	2.7	2.3	1.7	2.88
May	9.3	8.0	8.0	4.7	5.3	7.06
June	17.0	12.7	11.7	11.7	10.3	12.68
July	23.0	16.0	12.7	13.3	10.7	15.14
August	24.7	17.0	14.7	14.3	14.6	17.06
September	19.7	15.0	9.3	15.0	13.7	14.54
October	18.3	14.7	12.0	8.3	8.0	12.26
November	20.0	20.3	19.3	18.7	18.7	19.40
December	19.3	13.0	12.0	11.0	12.0	13.46
Year	189.3	144.7	131.3	117.9	114.6	139.36

A summary of the daily records on a weekly basis brings out the normal rainfall curve more clearly than does a summary by months. This method involved 105 records for each week distributed among the five stations, hence tends in a measure to compensate for the shortness of the period. In the graph, illustrating this summary, the climax of the *Verano* is shown as occurring about the last week in March, and of the *veranillo* in early October. The double rainy season culminating in late July and in November is also distinctly shown. A longer period of observations would undoubtedly change slightly some of the details but would probably retain the general form of the curve.

The following table gives the statistical summary upon which Figure 4 is based. From it, the rain probabilty for every week in the year can be estimated for the district as a whole, but it must be remembered that variability both with regard to place and time is so great, that here even more than is generally true, the suggested normal is an extremely unlikely occurrence. It would be very abnormal to experience the normal.

TABLE 11.—*Weekly rain probability in the Tela district*

[Based on daily rainfall records, 1924-1926]

Week	Average number rainy days	Per cent	Week	Average number rainy days	Per cent
1	3.25	46.6	27	3.27	46.6
2	3.13	44.7	28	3.60	51.4
3	1.47	20.9	29	3.73	53.3
4	2.26	32.3	30	2.87	40.9
5	2.40	34.3	31	2.93	41.9
6	5.60	51.4	32	4.67	66.7
7	1.60	22.8	33	4.87	69.5
8	2.00	28.6	34	2.67	38.1
9	2.73	39.0	35	3.86	55.2
10	1.06	15.2	36	3.40	48.6
11	1.33	19.0	37	3.53	50.5
12	.60	8.5	38	3.27	46.6
13	.00	0.0	39	3.27	46.6
14	.20	2.6	40	3.47	49.5
15	.26	3.7	41	2.60	37.1
16	1.07	15.2	42	1.80	24.7
17	1.20	17.1	43	2.93	41.9
18	.87	12.4	44	4.00	57.5
19	1.33	19.0	45	4.20	60.0
20	2.13	30.3	46	4.20	60.0
21	1.33	19.0	47	5.27	75.3
22	2.40	34.3	48	4.73	67.5
23	2.53	36.2	49	3.00	42.8
24	2.13	30.3	50	2.67	38.1
25	4.33	61.9	51	3.06	43.7
26	3.20	45.7	52	2.87	41.0

According to this record the average percentage of rainy days during the year is 38.2 for the five stations quoted as representing the Tela district.

Variability of rainfall.—The striking variability of rainfall as to time and place has already been alluded to. Instances are numerous where a rain of several inches may occur in a given locality, whereas but 2 or 3 miles distant hardly any rain falls. These local conditions are generally recognized. But seasonal and annual variability for a given locality is equally pronounced, and this condition is characteristic of the whole country rather than being unique for the Caribbean coastal plain.

The record of Tela (Table 9) for the 13-year period, 1914–1926, inclusive, gives ample evidence of annual variability. The highest yearly rainfall occurred in 1926, 128.71 inches, while the lowest, only 52.21 inches, was recorded in 1923. The dry year of 1923 was followed by 114.63 inches in 1924, thus giving an increase of 62.42 inches over the preceding year for the same place.

The monthly variability is as pronounced as is the annual. A glance at Table 12 will show some vivid illustrations of this fact. For example, March and April are presumably dry months at Tela, yet in some years March has had up to 13.66 inches and April 6.52 inches of rain, while in other years less than 0.25 inch rain has fallen during each of these months. June, ordinarily a wet month, has had as little as 0.66 inch, and November has fluctuated between 33.47 and 5.88 inches

TABLE 12.—*Monthly extremes of rainfall, Tela, 1914–1926, inclusive*

[Inches]

Month	Average	Maximum	Minimum	Number of years above or below average	
				Above	Below
January	8.46	21.57	3.21	7	6
February	6.38	16.25	1.76	5	8
March	5.47	13.66	.26	5	8
April	2.81	6.52	.23	7	6
May	2.73	8.45	.50	7	6
June	5.95	11.03	.66	5	8
July	5.86	9.71	2.60	6	7
August	7.82	13.38	3.85	6	7
September	8.81	20.78	5.27	5	8
October	11.32	26.61	6.40	5	8
November	16.71	33.47	5.88	7	6
December	12.29	29.26	4.35	4	9
Annual	99.68	124.92	52.21	6	7

SUMMARY OF THE CAUSES OF RAINFALL ON THE CARIBBEAN COASTAL PLAIN OF HONDURAS

The location of Honduras in what may be termed the border zone of the equatorial belt is largely responsible for the complexity of climatic conditions found there.

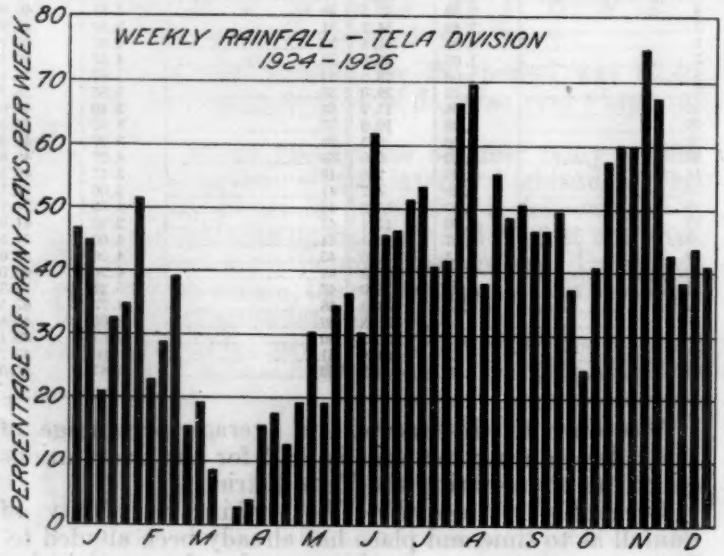

FIGURE 4.—Weekly rainfall—Tela division, 1924–1926

Seasonal variations occur, of course, with the north and south migration of the climatic belts, but variability is caused also by irregular penetration of equatorial and temperate weather conditions beyond their customary limits at various seasons. Thus at times in the winter months *northers* induced by pressure conditions in the central interior of North America sweep across the Gulf of Mexico and into the Caribbean borderlands, especially the north coast of Honduras, and give days of chilly, raw, drizzly weather. On the other hand, there are times when opposite conditions are true, and lobes of equatorial low pressure extend into the area even in the winter season. Thus Honduras, though dominated by the northeast trades, also is periodically affected by the equatorial calms, to a lesser extent by the extratropical high-pressure belt, and occasionally even feels the effect of the cyclones of the northern westerlies.

The basic causes of the rainfall on the Caribbean coastal plain of Honduras therefore appear to be:

1. The equatorial rain belt which extends across and beyond Honduras during the summer, the heavy rains lagging some weeks behind the vertical sun. This in large measure accounts for the heavy summer rainfall period.

2. The northeast trades, which, since leaving the West Indies, have traversed the warm Caribbean, bring the heavy rains of autumn, culminating in November. In that season the waters of the Caribbean are warmest and the receding sun gives rise to cooling of the land, hence maximum precipitation.

3. The "wet northers" which are produced by winds from the north after crossing the warm Gulf of Mexico.

4. Cyclonic storms which develop along border zone of high and low pressures and sometimes attain considerable violence, with resultant heavy rains.

Concomitant with these causes, consideration should also be given the narrowness of the plain, and the slopes of the adjacent border mountains. The relief undoubtedly has an important relation to the development of local convection currents and hence to local rainfall conditions. It is very possible that further study of the details of local relief may furnish the key that will account for some of the dry spots and some of the wet spots which are at present attributed entirely to variability and hence are considered to be purely accidental. There may be a reason in some instances—the story can not yet be finally told.

WEATHER ABNORMALITIES IN THE UNITED STATES

By ALFRED J. HENRY

[Weather Bureau, Washington, D. C.]

The study of weather abnormalities has a very real attraction for many students of the weather map. I consider such studies as among the most promising that can be made especially when the much greater problem of seasonal forecasting is in view. A better understanding of the causes of the irregularities or abnormalities of the weather must form a preferred avenue of approach to the problem of long-range forecasting.

Hitherto the lack of observational data for the more remote places on the globe has been so great as to seriously handicap any organized effort to elucidate the cause or causes of weather abnormalities. While the results of the efforts herein described are negative and the paper must be considered as of an exploratory character, it is printed in the hope that it may induce similar studies for other localities in the years that are to come.

The weather of 1915 in the United States and elsewhere in North America was abnormal in several respects, especially as to the distribution of temperature and precipitation over very considerable areas. From May to September the temperature was unusually low, in fact the mean temperature for the summer months June–August was the second lowest at many stations during the last 50-odd years.

The precipitation in one or more States west of the Mississippi, almost in the center of the continent was unusually heavy with the result that disastrous floods were produced in the streams of the region and a large property loss was entailed. The number of severe hailstorms in the Plains States was unusually large and the destruction of growing crops was very great.

Other exceptional weather phenomena were as follows: Three severe tropical cyclones from the Gulf of Mexico entered the continent and continued a long distance before dissipating, two in August and one in September, and finally two northers occurred in the Canal Zone in April—an event not hitherto recorded since the occupation of that zone.

From the foregoing it is apparent that the normal atmospheric circulation over the North American Continent for a part of the year at least, must have been materially disturbed. Let us first consider the temperature.

The distribution of temperature east of the Rockies is closely related to the prevailing direction of the wind and this in turn is controlled by the paths followed by cyclonic and anticyclonic areas in their movement across the country. When cyclones follow the northern circuit they induce southerly winds and when, as sometimes happens, the cyclones are not closely followed by strong anticyclones warm weather results. Warm weather also prevails in eastern districts, as pointed out by Humphreys, when the western part of the North Atlantic is occupied by mean pressure greater than normal. On the other hand when pressure over the western North Atlantic is low, northerly winds from the interior of the continent will be induced and the temperature in Atlantic coast districts sinks.

In the United States the locus of the greatest depression of temperature in May was over the upper Lake region, in June and July over the upper Missouri Valley, in August it had been shifted to the middle Mississippi Valley, and in September back far to the northwest in northern Montana. Thus it may be inferred that the controls were not the same for each of the months and this view is strengthened by the discovery of the initial cause of the cooling, viz, in the origin and movement of four vigorous anticyclones over or near to the west shore of Hudson Bay as recited in the following excerpt from the Canadian Monthly Weather Review for May, 1915, page 65.

HIGH AREAS.—Seven areas of high pressure were traced. One first appeared over Alberta, *four over or in close proximity to the western shores of Hudson Bay* (*Italics mine*), one on the coast of the Middle Pacific States, and one in southern Montana. The four areas from Hudson Bay were quite remarkable for the season of the year. Spreading southward to the Great Lakes, and very energetic, they caused a great preponderance of cold, dry north and northeast winds, as well as frost on several occasions, from Ontario eastward, the latter doing more or less damage locally to vegetation. The system which appeared near Port Nelson on the 25th, reached northern Michigan on the 26th, then receded and lay to the northward of the Great Lakes until the close of the month. It was attended by sharp frosts from Ontario to the Maritime Provinces, an occurrence which seldom happens so late in the season.

It is conceivable that a snow cover in the region about Hudson Bay would tend to facilitate the formation of intense anticyclones. Inquiry addressed to the Canadian Meteorological Service elicits the information that no unusual surface conditions existed in May, 1915. I quote from the letter of Mr. A. J. Connor, climatologist, especially as to the possibility of the bay freezing over in winter:

There is always some traveling during a winter along the shore ice of Hudson Bay, from post to post, by the factors or their people, but beyond this the bay is deserted in the winter. The question of ice in the bay has, however, come up at parliamentary and departmental discussions several times. These discussions have caused searches of the records of the Honourable Company of Gentlemen Adventurers trading into Hudson's Bay since Prince Rupert's first charter, as well as inquiries into other sources of information. The conclusion is that Hudson Bay has never frozen over in historical times. Heavy shore ice forms and ice fields of varying extent float in the bay, but it has been stated that a properly equipped ship could navigate in the bay itself all winter.

The records from Nelson and from Hudson Strait in 1915 make no mention of any unusual occurrence, so that we may assume that ice conditions did not differ (noticeably to our observers at least) from the normal.

The tracks of pressure maxima were charted by Mr. Webber, who was in the service at that time (May 1915), from the data then in hand, but since our radio service was not then in existence he had very little to work upon in the north. Material which we received long after that date by mail indicate that the "four energetic anticyclones" were extensions or tongues of a pressure maximum which persisted all month in the regions of the archipelago. The flow of air on the eastern side of this area during a large part of the month was apparently so arranged that the circulation was from the Ellesmere side of the polar basin south, but also spreading fanwise west over a large part of the continent. The temperatures were not low, the mean for the month in Baffin Land was normal, at Nelson about 2½° below normal.

At Bernard Harbor (70° N.; 115° W.) the pressure rose to about 30.70 inches on some days and above 30.90 inches on the 17th, but the maximum was evidently always east of this point, on most days evidently in the archipelago; though toward the close of the month it would seem that there was a maximum in a more southerly latitude, connecting by a neck of high pressure with another maximum near or beyond the pole.

* * * The general effect during the month was of a moderately cold front of quasi-maritime character from the eastern polar region, flowing fanwise south and west into the interior of the continent. A part of the warm front from the Caribbean area passed west and up the western side of the continent into the circulation from the Pacific. A part of the remainder of the warm front attempted to pass up the center and east of the continent, but was frequently forced to rise in the environment created by the northeast polar front cutting in on both flanks.

In the January, 1929, REVIEW, page 22, mention is made of several cyclonic storms which after reaching the coast of Newfoundland were displaced northwestward into the interior as far as Hudson Bay. The fact that there is open water in the bay in winter is evidence of the existence of a relatively warm column of air over that body of water. This air, due to the existing baric gradients, would be blown to the southeast and over the Canadian Maritime Provinces, and this fact may, in part, explain the abnormal course pursued by the cyclonic storms in question.

The cause of the cool weather in May, 1915, is thus definitely determined; it is not probable that the cool weather of the succeeding three summer months was wholly due to the same initial cause.

Assuming that the primary control of the winds rests in the pressure distribution, I have constructed charts of monthly mean pressure anomaly for the Northern Hemisphere for December, 1914, up to and including July, 1915. The pressure anomalies of this period were rather pronounced in those parts of the globe that are naturally subject to large pressure fluctuations. The charts for January–June, 1915, are shown in reduced size in Figure 1.

Owing to the small number of normal pressure stations in the Northern Hemisphere, 256 for January, there must be some uncertainty in the course of the lines of zero change, especially over the oceans and in the Arctic, where there are no observing stations.

While it is not safe to generalize from a very few charts, nevertheless one or two tendencies may be noted, first, there appears to be a progressive movement from west to east of pronounced pressure abnormalities, although there is no definite rule as yet apparent; second, there is a tendency toward a reversal of sign in the pressure abnormality from one month to the next in any region, and the same rule is more or less applicable to all other meteorological elements. Also it may be remarked that the amplitude of pressure oscillations is much greater in high than in low latitudes and that certain regions of the Northern Hemisphere are particularly susceptible to large pressure oscillations such as areas of great temperature contrast—the Iceland region and northwest Europe,

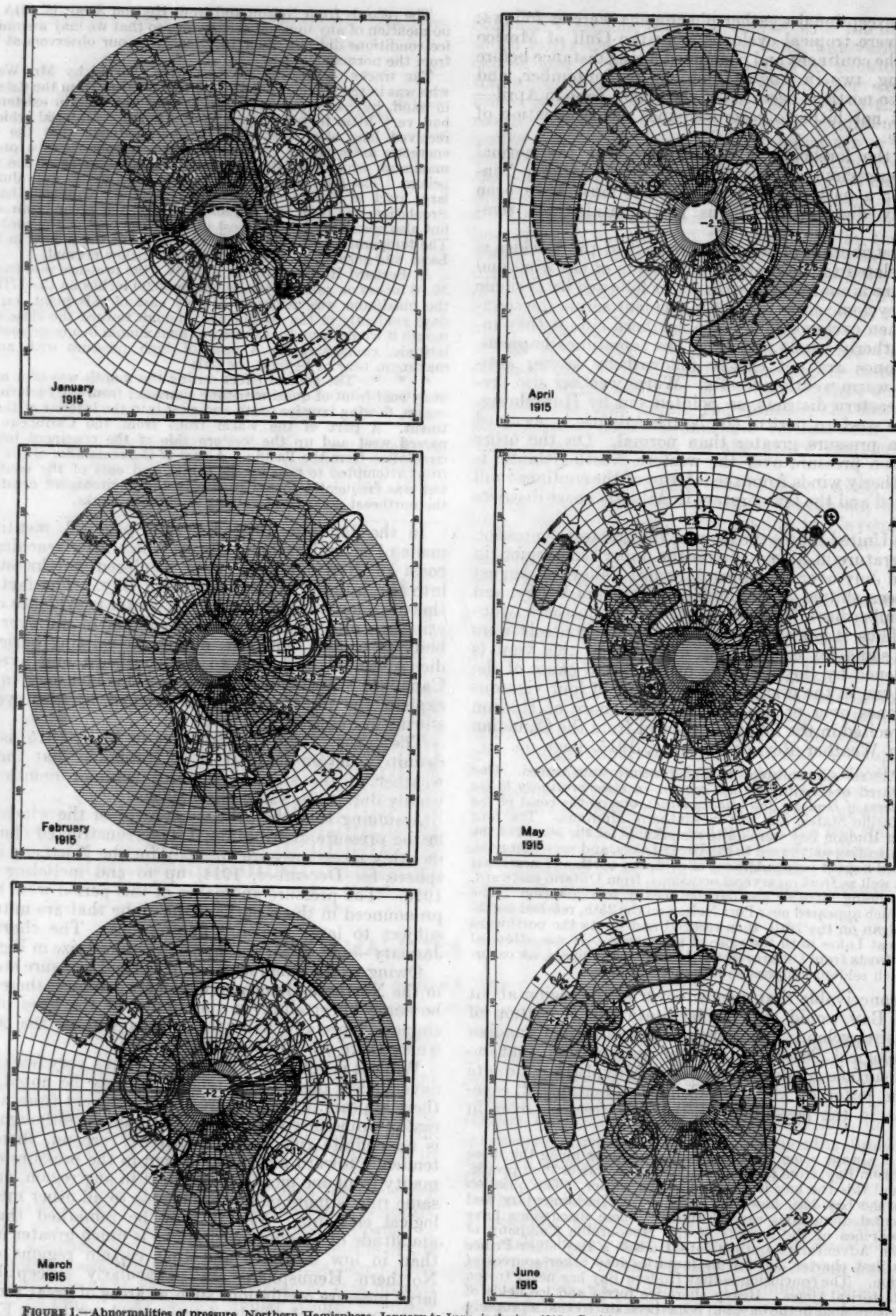

FIGURE 1.—Abnormalities of pressure, Northern Hemisphere, January to June, inclusive, 1915. Positive areas are shaded, negative areas unshaded

for example. The continent of Europe is much more subject to large pressure oscillations that that of North America.

As a rule the charts speak for themselves; I shall discuss very briefly those for March to June, inclusive.

March, 1915, Chart D.—This chart as compared with that of the previous month shows evidence of a progression of the abnormalities from west to east and also of the development of a strong negative isabnormal over the North Atlantic where the previous month showed a moderate positive isabnormal; the greatest negative abnormality was recorded at St. Johns, Newfoundland, 16.1 mb. (0.48 inch). This abnormality stretched across the Atlantic and impinged upon the northwest of Africa. The Siberian negative isabnormal of February apparently advanced to Alaska being replaced by a positive isabnormal of considerable magnitude.

In this month high pressure was the rule in the Arctic, the single exception being in the case of Dutch Harbor which recorded a negative isabnormal of 9 mb. (0.26 inch). The temperature in the United States was mostly below normal, the definit reaching 9° to 12° over the Plains States and Texas, while in Pacific Coast States and the plateau region negative anomalies prevailed. Precipitation was below normal in the great majority of districts.

April, 1915, Chart E.—In this month there is a suggestion of a ridge of high pressure that almost encircles the globe in rather low latitudes being interrupted only over the central and eastern Pacific. On the polar side of this ridge are two negative isabnormals on opposite sides of the globe. A pressure distribution such as this is conducive to warm, dry weather in temperate latitudes.

May, 1915, Chart F.—In this month high pressure in the Arctic save for a sector in northern Europe is the dominating influence. Pressure in the Tropics is prevailingly low, but since the oscillations there are of small amplitude lines of equal abnormality have not been drawn. The opinion is expressed that the positive isabnormal that extends westward from the coast of Norway includes that part of North America above latitude 50° N., a region in which there were very few meteorological stations in May, 1915. Information received from the Canadian Meteorological Service, previously quoted, supports this conclusion, and it may be concluded with much confidence that the abnormal temperature of that month in the United States and Canada was due to the high pressure in the Hudson Bay region as previously indicated.

June, 1915, Chart G.—The outstanding feature of the June and July charts is the high pressure in the polar region, and this is also true, though in less degree, for August of the same year.

FLOODS IN MISSOURI VALLEY, HAIL IN PLAINS STATES

Heavy and continued rains in the lower Missouri Basin in May continuing into June resulted in disastrous floods in that basin entailing a monetary loss of over $6,000,000. The details may be found in this REVIEW for May and June, 1915.

The loss from damaging hail storms in Kansas and adjoining States was exceptionally heavy. The hail fell almost coincidentally with the ripening of the wheat crop, thus causing a very heavy loss.

Both the heavy rains and the large number of hail storms in May and June, 1915, are, in the opinion of the author, directly due to the high pressure in the Hudson Bay region, which retarded the northeastward course of low-pressure areas passing across the Plains States, thus permitting them to precipitate large quantities of rain.

Fortunately further details as to the pressure distribution over Siberia for the winter of 1914–15 are available in the work of Grebojedov[1] who has considered the pressure over that region from November, 1914, to March, 1915, as a whole and also in five subperiods as follows:

(*1*) *November 1 to 27, 1914.*—A period of positive pressure anomaly over Siberia with two centers of large anomaly, the first over the lower Ob Valley, plus 4 mm., and the second of 6 mm. directly east of Lake Baikal centered at a single station, probably Tchita.

(*2*) *January 3 to February 4, 1915.*—A second period of very large positive anomaly over Siberia, disposed geographically precisely as the one just described with this difference, the positive anomaly over the lower Ob Valley being 12 mm. and east of Lake Baikal the same; there was also a negative anomaly over the Caspian region of 2 mm., and this region of negative anomaly extended eastward as far as the ninetieth meridian of east longitude.

(*3*) *February 21 to March 12, 1915.*—A third period of positive pressure anomaly disposed precisely as the two first described but of somewhat less intensity.

(*4*) *November 28, 1914, to January 2, 1915.*—A period of pronounced negative anomaly over central and northeastern Siberia, the negative anomaly being 10 mm. at about 62° N. and 130° E., diminishing thence southeastward to zero in the latitude of Lake Baikal and changing to a positive anomaly southward.

(*5*) *February 5 to 20, 1915.*—A second period of pronounced negative anomaly over the same region as just described, the maximum negative anomaly being 12 mm. at the same geographic point as before diminishing thence southward and southwestward and naturally changing to positive anomaly that amounted to 7 mm. in the Caspian Sea region.

Thus he shows that over Siberia and probably a great part of Asia there were five major pressure oscillations between November 1, 1914, and March 3, 1915, and that the sequence was as follows plus-minus-plus-minus-plus. The average duration of each pulsation was 24 days although the last one was but about half that number. It may be concluded that these pulsations or oscillations dominated the weather of the greater part of Asia. The significant feature, however, must be the fact that cyclonic storms or depressions must have been in evidence over the most inhospitable terrain for such storms to be found in any other part of the earth except the very high latitudes. The résumé of International Meteorological Observations issued by the Weather Bureau under the title "Bulletin A, Washington, 1891," clearly shows that the region east of Lake Baikal in Siberia is less frequented by cyclonic storms than any other equal area in the same latitude around the globe. It would seem that such an exceptional phenomenon must be reflected in other parts of the globe. Unfortunately for our purpose, however, there are no means at hand to determine whether the cyclones of northeast Siberia from November 28, 1914, to January 2, 1915, endured long enough to reach North America.

Daily weather charts for the North Pacific would aid greatly, but these are not available and we must have recourse to the weather summaries issued by the Canadian Meteorological Service and the United States Weather Bureau for the North American Continent. These show that the month of December, 1914—a month of low pressure in Siberia—was essentially a month of high pressure in Canada and the United States with temperature considerably below the normal. The anticyclones of Canada, of which there were nine, were for the most part vigorous, widespread, and persistent; they were attended by much cold weather. Pressure in the United States, especially in Alaska was high and temperature

[1] Grebojedov, S. Les cycles périodiques accomplis dans l'activité' de l'anticyclone de Sibérie. Recueil de Géophysique, tome III, fasicule 3, 1916. Publié par L'Observatoire Physique Central Nicolas.

below the normal. The pressure in North America was therefore directly in the opposite sense to that in Siberia. Considering next the second period of low pressure in Siberia, viz:

February 5 to 20, 1915.—A month of unusually low pressure in central and northeast Siberia; while nine anticyclones were charted in Canada, it is said of them that they were not as energetic as is often the case in the winter season and their accompanying cold waves also lacked intensity, the result being a mean temperature in Canada very much above the average. During this month low pressure had overspread northwest Canada and the United States west of the Rockies, and the temperature everywhere in the latter except in Arizona and western New Mexico was considerably above the normal. Precipitation was abundant on the Pacific coast, the Missouri Valley, and the upper Mississippi Valley. The inference from the foregoing seems to be that the low pressure in Siberia had spread eastward across the Pacific into Alaska and over the western part of the continent as far south as Mexico. On the eastern seaboard, however, the opposite pressure conditions prevailed.

Consider now the three cases of high pressure in Siberia. I remark first that the time intervals of these, viz, November 1 to 27, January 3 to February 4, and February 21 to March 3 do not except in the two cases first mentioned lend themselves to direct comparison with calendar month means.

November 1 to 27, 1914. A month of high pressure in Siberia.—Pressure in Canada and the United States was not far from normal with a tendency toward high pressure in the western part of the continent, except that low pressure was the rule in Alaska and northwest Canada. Nine anticyclones were charted in Canada and 13 in the United States, 5 of the latter coming from Canada. In general they were lacking in intensity and, partly due to that fact and partly to the movement of a large number of cyclones eastward along the border between Canada and the United States, the month as a whole was warm from the Atlantic to the Pacific and as a rule dry.

January, 1915: High pressure in Siberia.—Pressure was half an inch below the average at Dawson, Yukon Territory, and a less amount generally throughout northwest Canada; while 10 anticyclones were charted in that country they were not of the energetic type often prevailing in January. Fourteen cyclones were charted, half of which first appeared on the Alaskan coast or in other words along the eastern margin of the winter anticyclone of Siberia. In United States pressure was low in many parts of the country, the greatest departures being in the lower Missouri Valley, Kansas, northern California and western Oregon, and western Washington. Thirteen anticyclones were charted, eight of which came from Canada and four from the Pacific. The temperature was close to normal in all parts of the country and precipitation was fairly abundant in the majority of districts.

It must be confessed that the pressure level in the region usually occupied by the great winter anticyclone of Siberia does not appear directly to greatly modify or influence the weather in North America either currently or subsequently. Indirectly, however, it may enter as a causative influence, thus when pressure is much above its normal level in Siberia low pressure is likely to be the rule on its eastern margin which in turn makes for mild winter temperature and diminished precipitation in North America; on the other hand when pressure is much depressed in northeast Siberia, the probabilities are that pressure over Alaska and northwest Canada will be high and thus create low temperature and moderate precipitation in North America. The evidence is however incomplete and inconclusive.

NOTES ON LINE SQUALLS

By C. G. ANDRUS

[Weather Bureau, New York, N. Y.]

Line squalls have earned for themselves a reputation of severity and malevolence which has made airman deal with them with respect and caution. Fatalities and crashes, frequently with open gun, have been traced to line squalls as the direct or contributory cause in a large number of wrecks attributed to weather. Unlike fog, which is more or less quiet it is an active, moving, and transient expression of meteorological violence and it may generally be observed before its onset and occasionally anticipated with great accuracy. Half the battle so far as the airman is concerned is to be prepared for it; to do this it should be recognized both by its indicative characteristics on the weather map and its actual appearance in the air.

To spot the conditions favorable to line squalls on the weather map it requires that we divide the depressions or "lows," and even the troughs between highs into warm and cold sides. The warm side indicated by southerly winds (SE. to SW.) is found on the lower part of the front of the low; behind the low are NW. winds (W. to N.) and comparatively cold air. Occasionally the question arises quite honestly "what occurs where they meet?" They do not meet in the sense of colliding in an impact, but the cold air by virtue of its heavier weight wedges under the warm breezes from the south which are quite ready to rise as a result of their lighter weight. Where this undercutting cold "front" curls up before it the lighter and usually moist warm air, a long line of squalls and low-arching clouds are now formed as sufficient chilling by both contact and raising condenses the water vapor into rolling clouds, which frequently reach well above the ceiling of ordinary airplanes. The lifting action is rather violent and sudden and the resulting condensation into clouds is abrupt and intense, so that the phenomena associated by experienced airmen with such condensation are frequently found highly developed. The thunderstorm, sleet, severe snow, and extraordinary instability and bumpiness may all be present within the squall which is itself moving forward usually at about 15 to 30 miles per hour toward some easterly direction.

Once detected, their line of march may be timed quite accurately, although it is not equally easy to predetermine their violence which is variable and capricious. The "northers" of the Plains States are line squalls and are sometimes entirely of wind, the moisture supply on both sides of the depression being too scanty even for clouds. Nearer the Lake region and along the Gulf and Atlantic coasts they tend to be "wet" as well as windy. Unfortunately adding moisture to the problem tokens more violence produced by heat liberated by the condensation, as well as nullifies visibility and even ceiling for the airmen. Safety lies in getting through the squall cloud as rapidly as possible, at the same time maintaining a sharp lookout for any brightening areas ahead. All this must

be done at a fair altitude, 4,000 or more feet above the ground so that the violent vertical currents will not dash the plane to the ground. Ice and sleet add to the hazards which dictate altitude as desirable. There seems to be little choice as to which is safer, coming up on the lines squall from its rear or its front; it is undeniably easier to detect it and prepare for it when the plane is running to meet it because its front is more defined than the more trailing characteristics of its rear.

It is noteworthy that many difficulties and crashes caused by line-squall phenomena have occurred in the dark hours, which leads to the conclusion that they were mistaken for large thunder and rain storms in the darkness, whereas their "line" features would have been at once recognized and properly met in daylight. This suggests some careful scrutiny of the weather map as a real aid, with the rule in mind that wherever there appears a marked line along which conflicting winds with strongly contrasted temperatures there, one will find line-squall developments if the line runs southward or southwestward from the central portion of the low. British meteorologists have studied line squalls with a thoroughness born of danger; their practice of giving the squall its victims' names is perhaps not particularly unctuous, but at least compelling of attention and the dramatic possibilities of the details of the *Eurydice* squall where would be portrayed the last moments of a great training ship caught unawares by a line squall might indelibly point a moral of value.

In the air these squalls have taken tolls of life and property in the heavier-than-air ships and we recall the line squall which swept eastward between Chicago and Toledo on the evening of November 29, 1927. It passed just east of Chicago at 7 p. m. and 12 hours later the weather map clearly delineates it near Cleveland. About 10 p. m. in the eastbound mail plane, pilot Axberg crashed into the ground near Goshen, Ind., in the midst of a violent squall. Undoubtedly it was the line squall, met in the darkness by the pilot, who overtook it from the rear, perhaps unaware that the gathering obscurity culminated ahead of him in a climax of violent snow, great air bumps, and annihilated vision. The line of squalls passed there at that time and even on the ground was of great although passing violence.

Of similar nature and likewise a manifestation of great severity was an outburst of wind and blizzard conditions which swept eastward toward Cleveland on the afternoon of December 20, 1928, and was the occasion of the fatal crash of the air-mail plane, westbound from Cleveland with Pilot Leo McGinn, near Sandusky, Ohio, at 6 p. m. This squall reached phenomenal violence and was particularly dangerous because of the low temperatures and heavy snow. The onset of it at Cleveland brought a blinding snow storm during the last of the SSW. winds followed by decidedly colder weather and westerly gales; the temperature fell 9° and the pressure rose one-twentieth of an inch during an hour and visibility and ceiling were practically reduced to zeros during the passage of the storm. In the terrible commotion and violent currents and probably beset by ice-forming conditions in addition to the other difficulties, McGinn's plane was swept to the ground.

It was once remarked by Pilot J. D. Hill (of *Old Glory* fame) that to attack a line squall cloud was attended by tantalizing uncertainty as to the proper place to drive into it, for what appeared at one moment to be a brighter and less "dirty" zone in the clouds would suddenly transform itself into as black and ugly a cloud as was present and once firmly convinced that to go through was the proper thing to do it might as well be penetrated at any point providing altitude and engine power were sufficient.

There is probably little in the account of the crossing of a number of line squalls by Kingsford-Smith over the Tasman Sea which has not been experienced at one time or another by the regular mail pilots of the lines near the Great Lakes. Accounts like this are rare however and we indulge in reproducing a part of the story here for that reason and also with the hope that accounts of phenomena met with in these line squalls may be inspired from the pens of those who come through them. The account is taken from the Quarterly Journal of the Royal Meteorological Society (British) January, 1929, number, as written by Director Kidson of the Dominion Meteorological Office. The flight lasted 14 hours and was from Australia to New Zealand, and for some unannounced reason was undertaken while a depression with line squalls was also crossing the Tasman sea. The plane left Australia at 5:25 p. m. September 10, 1928, heading east-southeastward:

> At an altitude of 3,200 feet and a speed of 76 knots (88 miles per hour). The sky was partly cloudy and the visibility rather low. At 7:50 a very high cloud bank was seen ahead and at 7:55 p. m. lightning could be seen. At 8:45 the altitude was 5,400 and climbing. It was commencing to be very bumpy. At 10 p. m. the altitude was 8,000 feet and three separate thunderstorms were visible. The aviators were hoping to pass over the storm ahead of them. At 10:10 no rain had been experienced but the lightning flashes were becoming blinding. At 10:15 heavy rain was encountered, the altitude being 6,800 feet; the lightning flashes were very close. Bands of light encircled the propeller tips being about 9 to 12 inches wide around the center and narrower around the outside propellers. The light around the center propeller seemed to be bluish in color; occasionally the glow extended right to the hubs of the propellers. It would disappear after the lightning discharges and gradually recover. On two occasions the searchlight (30 volts 1,500 watts) was lit up by the current passing through it. The following hour was the worst experienced. Ice, apparently from supercooled raindrops formed on the windshield, the undercarriage, the engine bearer shafts, and the wing itself. It was subsequently estimated that at one stage the machine carried a half ton of ice. Hail was met with at times and the leading edges of the propellers, which consisted of a compressed cotton fabric were badly torn by it. It became very wet and cold in the cockpit. At 12:15 a. m. there was a calm interval with improved weather. At 12:20 another very severe rain and lightning storm was experienced, vertical velocities of 3,000 feet per minute being recorded. On one occasion there was a fall of 300 feet. The ice on the wings became thicker and in very severe bumps the plane was forced down from 7,000 to 2,000 feet. At 12:30 it was fine again and stars were seen. At 12:40 heavy rain and very severe bumps were again encountered. Ice remained on the machine and it was bitterly cold; the altitude was then 8,000 to 6,000 feet. At 1:45 the worst weather was past.

The account continues with the landing at Christchurch at 7:50 a. m. with improving weather and bumpy air and states that "when thunderstorms were first met and before the 500-foot wireless aerial could be wound in a discharge passed through it and damaged the 600 m. wireless set."

Those who fly largely in mountainous regions may find some consolation in the accepted and logical belief that the severest squalls occur over flat country near abundant sources of moisture, thus partly disposing of the dangers attendant upon blind flying at increased altitude, a maneuver which seems to have more to recommend it than the tactics of hedgehopping beneath it and taking the chances of being hurled to the ground in the violent vertical drafts of air met in that narrow margin of altitude. Ordinary planes may have little chance of hurdling above a line squall of the more boisterous type as the piled up vertical currents throw cumulus clouds with thunderstorm caps up into the cirrus levels at 20,000 feet, and ice and snow prevail. Pilots whose blind-flying is ragged

ought not to be encouraged to get more experience by taking the offensive with a line squall, but may learn something of its wiles by getting set down on a good field well in advance of the roll cloud of the squall and making sure of some shelter. Once passed the squall will be followed by the weather of the other side which is not uniformly good but often marked by bumpy, rough, colder air, with numerous snow or rain squalls, scudding clouds and varying visibility which finally ease up when the colder change attains full possession of the territory.

EVAPORATION FROM RAIN GAGES

By HARRY G. CARTER

[Weather Bureau Office, Lincoln, Nebr.]

To determine the amount of water that would evaporate from a rain-gage measurements were made at Lincoln from May 1 to September 30, 1928. A standard 8-inch gage with receiving funnel and measuring tube in place was used in making the measurements. The water was placed in the measuring tube, the depth ranging from 5 to more than 10 inches (measuring 0.50 inch to more than 1 inch on a regular measuring stick). Readings were made at the time of the regular 7 a. m. and 7 p. m. observations.

The measurements were not in any way intended to determine the exact amount of evaporation from a free-water surface, but merely to give an indication of the amount of water that would evaporate from a rain gage during the interval between the ending of a rain and the measuring of the water.

The results of the measurements indicated that the daily evaporation averaged nearly 0.02 inch each 24 hours during May and approximately 0.01 inch each 24 hours during June, July, August, and September. Measurements also indicated that practically two-thirds of the evaporation occurred during the 12 hours between 7 p. m. and 7 a. m. Whether this was the actual condition or due to the crude method of measuring evaporation with a measuring stick with relatively large units, is questionable. But every month showed the greatest evaporation during the night.

Table 1 shows the average evaporation for the two 12-hour periods for each month during which measurements were made.

Since practically all the cooperative observers, at least in Nebraska, measure rainfall but once each day, usually late in the afternoon or early evening, it would seem that there is a possibility that between 0.01 and 0.02 inch of water would evaporate from the gage before the rain was measured, particularly so when the rain fell a short time after observation and the water stood in the gage 15 to 20 hours before being measured.

TABLE 1.—*Evaporation from a rain gage at Lincoln, Nebr., from May to September, 1928*

	May	June	July	Aug.	Sept.
Average evaporation:	*Inch*	*Inch*	*Inch*	*Inch*	*Inch*
For the 12 hours, 7 a. m. to 7 p. m.	.005	.003	.002	.003	.004
For the 12 hours, 7 p. m. to 7 a. m.	.012	.006	.007	.006	.008
For the 24 hours, 7 a. m. to 7 a. m.	.017	.009	.009	.009	.012
Average percentage of total evaporation:	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
For the 12 hours, 7 a. m. to 7 p. m.	29	33	22	33	33
For the 12 hours, 7 p. m. to 7 a. m.	71	67	78	67	67

During the months when precipitation is practically all in the form of rain, say from the 1st of April to the last of September, there are, on an average, between 45 and 55 rainy days in Nebraska. Since approximately two-thirds of these rains fall during the night hours and the water is not measured until late the next afternoon, it would seem that there would be a loss of water by evaporation amounting to between 0.30 and 0.60 inch during the six months.

From the above it would appear that cooperative observers should be encouraged to measure rainfall after each fall, or if this is impracticable, as it would be in many cases, to make measurements both morning and evening, keeping in mind that the amount to be entered on the daily record should be the amount that fell during the 24 hours ending at the hour of observation

COAST FOGS AND RADIOBEACONS

By WILLIS E. HURD

[Weather Bureau, Washington]

Recently in connection with a study of fog at sea, made at the central office of the Weather Bureau, there arose an informal discussion with the Lighthouse Service as to whether, fog being present at a given lighthouse, say on the southern New England coast, one might reasonably determine upon the probabilities of simultaneous fog occurrence at another lighthouse a considerable number of miles distant.

While there are many instances of fog obscuring in an unbroken sheet a long stretch of sea off the coast, more frequently such surface condensation is of a spotted character, depending upon the local contour of, and amount of sea envelopment by, the adjacent land; neighboring conditions of atmospheric pressure; the direction and steadiness, or variability, and force of the wind; the differences in temperature between adjacent water surfaces, or between that surface and the overlying air, etc. In almost any case there is great difficulty attending the successful forecasting of sea fogs.

Apart from the purely meteorological probabilities involved, it is interesting to note that various light stations incidental to their position finding signals by radiobeacon, are giving special information as to fog and thick weather whenever it exists in their vicinity.

In the Lighthouse Service Bulletin of the Department of Commerce for March 1, 1929, appears the following item bearing upon this subject:

FOG INFORMATION BROADCAST FOR SHIPPING

In addition to their primary purpose of providing signals on which ships can take accurate bearings by radio, the radiobeacon system incidentally broadcasts valuable information as to fog and low-visibility conditions along the coast.

These signals are operated during fog or low visibility and are silent in clear weather, excepting for certain regular time schedule operating periods, which are published for each station. Therefore, a navigator has a

ready means throughout the 24 hours of ascertaining the visibility conditions on any part of the coast by listening in for a desired radiobeacon at any time other than its scheduled period.

As the radiobeacon signals may usually be heard at distances of 200 to 300 miles, this should often furnish useful or valuable information both to vessels approaching from seaward and to those bound along the coast. The radiobeacon system is now sufficiently extended that the signals overlap along the entire coast, and the signals from the 37 radiobeacons on the Atlantic, Gulf, and Pacific coasts now spread out over a sea area of over a million square miles.

Navigators have been availing themselves of this source of weather information, and it has been particularly mentioned in reports recently received from Commodore Hartley, formerly of the *Leviathan*, and Captain Williamson, of the *Kentuckian*. In one case Ambrose radiobeacon was used when passing Nantucket Lightship to judge of conditions at the entrance to New York, and in the other Blunts Reef radiobeacon was used by a coastwise vessel to ascertain conditions ahead of it.

TORNADOES IN KANSAS

By S. D. FLORA

Tornadoes are more numerous in May and June than any other time of the year in the Middle West, according to records of the United States Weather Bureau. In Kansas 53 per cent of the 177 tornadoes that have struck the State since 1913 have occurred either in May or June. The only months entirely free from them in the State in that time are January and December.

In the 13 years ending with 1928 more tornadoes occurred in Kansas than in any other State, as shown by a summary of the Weather Bureau record obtained through its network of almost 5,000 stations. When relative areas of States is considered, however, it is found that both Iowa and Arkansas have experienced more tornadoes in that period than Kansas. Actual damage by these violent windstorms has been immensely greater in Missouri than in either Kansas, Iowa, or Arkansas. Illinois, Indiana, and Ohio have also had a bigger tornado loss than the Sunflower State, largely due to the same cause.

The year 1928 set a new high mark for tornado frequency in Kansas, with a total of 26 recorded against a 15-year average of slightly less than 12. Kansas tornado losses for the period totaled $9,547,150 and 102 persons were killed, according to official estimates. This may seem high in the aggregate, but it is less than two-fifths of the property loss of the St. Louis tornado on September 29, 1927, and the fatality list is not a sixth as great as that of the tri-State tornado that struck Murphysboro, Ill., March 18, 1925.

One reason why Kansas tornado losses have been small, comparatively speaking, is that tornadoes in that State seldom travel more than 25 miles before they break up. In the Mississippi Valley some of them travel 50 to 150 miles. In Kansas a great many tornadoes pass over prairie country, where buildings are few and far apart, and finally draw up into the clouds with no more damage than a few out buildings wrecked and telephone lines and wind mills blown down. Kansas people in one respect, at least, are more fortunate than their eastern cousins. In most sections of the State the funnel shaped cloud can be seen approaching for several miles and there is a chance for a run to shelter in basements or "cyclone cellars." The latter, which are merely outdoor caves, are common sights near farm houses in central and western Kansas, where they are used for storage of vegetables and dairy products. Many a Kansas farmer and his family have emerged unhurt from a handy "cyclone cellar" after a tornado has passed over and house and barn have been swept away by the wind.

Only three Kansas tornadoes have been in the million-dollar class. One that struck Great Bend November 10, 1915, killed 11 persons and destroyed property to the estimated extent of $1,000,000. Another struck in the oil fields of Butler County July 13, 1924, tore up Augusta, played havoc with oil rigs, and caused a total loss of $2,000,000 and one person killed. The Hutchinson tornado of May 7, 1927, left its trail in five Kansas counties, Comanche, Barker, Kingman, Reno, and McPherson, killed 10 persons, and destroyed property to the extent of $1,300,000.

Tornadoes are undoubtedly more numerous than most persons realize. St. Louis has had two violent ones, on May 27, 1896, and again on September 29, 1927. Omaha had two that caused great destruction; the Easter storm of March 23, 1913, and another April 6, 1919. St. Joseph has seen four tornadoes in the past 14 years: One April 2, 1913; one March 3, 1923; one June 24, 1924; and the last on May 24, 1927. The Kansas Cities have two tornadoes in their history. The first struck Kansas City, Mo., May 11, 1886, and the last reached the western suburbs of Kansas City, Kans., July 16, 1927. Topeka has seen two tornadoes in recent years, but both were in its suburbs and caused very little damage. A violent tornado on June 5, 1917, registration day, missed Topeka by only a few miles. Four destructive tornadoes formed within a radius of 80 miles of Sioux City, Iowa, on September 13, 1928, and one of them, headed almost directly for the city, ended only 5 miles from the suburbs.

Science has devised no way of predicting when or where a tornado will strike or exactly what path it will travel once it starts. Weather Bureau officials recognize certain conditions that are favorable—sultry, "sticky" afternoons following mornings that are oppressive, especially in May and June, with an area of low atmospheric pressure shown on the weather map to the northwest—but the Weather Bureau makes no predictions of tornadoes. Even when conditions are apparently most favorable tornadoes may not occur at all and when they do appear there is no certainty in regard to what locality or even what State they will strike. Also, no successful effort has ever been made to warn cities of the approach of a tornado when it is traveling in their general direction. Wire service is always disrupted by such a storm and radio would be worthless on account of disablement of a sending station in the storm path. The tornado that struck Hutchinson, Kansas, May 7, 1927, had been traveling in a sweeping curve that carried it in a general direction toward that city for five hours before it finally struck. It narrowly missed one county seat and several small towns on the way and was seen by hundreds of persons, yet Hutchinson had absolutely no warning of its approach.

Personal safety when a tornado is approaching is either a matter of luck or the exercise of swift judgment. Ac-

counts of tornado disasters are filled with reports of escapes that seem little short of miraculous and of sudden deaths from falling timbers, bricks, and stones.

The old-time "cyclone cellar" or outdoor cave has probably been the means of saving more lives from tornadoes than anything else and is still one of the best places of refuge ever contrived. The southwest corner of the basement of a frame house is almost as safe, especially if a person crouches close against the wall. Tornadoes nearly always approach from the south or west and flying débris or perhaps the house itself will be carried away from the southwest corner. The basement of a brick or stone house is liable to be a death trap in a tornado as brick or masonry walls are liable to collapse and tumble down anywhere.

A person caught in the open when a tornado approaches has a choice of lying down flat in a depression or of flight. Tornadoes travel across the country at a rate of 30 to 60 miles per hour, usually, and escape for a person in an automobile is simple if there are highways open. A person on foot directly in the path of such a storm should run toward the northwest, which is at right angles to the storm path and toward the side where the winds are least violent.

For a person caught in the business section of a city when a tornado is approaching perhaps the best chance would be to stand close to an inside partition of a modern reinforced steel and concrete building. Architects believe such buildings will resist side winds of a tornado and possibly to a considerable extent the full force of such a storm, though this has not been established definitely. In any case outside walls are more likely to be blown out than inside partitions and the latter might serve to protect against débris that falls from upper stories.

ÅNGSTRÖM ON RECORDING SOLAR RADIATION: A STUDY OF THE RADIATION CLIMATE OF THE SURROUNDINGS OF STOCKHOLM

By HERBERT H. KIMBALL

[Meddelanden Från Statens Meteorologisk-Hydrografiska Anstalt. Band 4. No 3; 36 pp., 2 Pl. 23 text fig.

In his preface the author states that:

It is desirable that the results as regards the total radiation income from the sun and sky be brought into relation, not only with the variation of the dark outgoing radiation, but also with the radiation within special limited parts of the spectrum. In fact it is planned to add later to the present study a detailed treatment of these last-named questions.

The following quotations are from the introduction:

Practically all the energy conveyed to the earth and its atmosphere is furnished by the radiation from the sun; and the only way in which this energy is able to escape from the system is through radiation back to space from the surface of the earth and from the atmosphere. Together with the processes of atmospheric circulation, through which advection and convection of heat is sustained, this uninterrupted exchange of radiation determines the horizontal and vertical distribution of temperature within the atmosphere. In fact, these two groups of phenomena, the circulation and the radiation processes within the atmosphere, are involved in one another to such a degree that it seems scarcely appropriate to speak of the one as more fundamental than the other. So much seems certain, however, that we shall never arrive at a clear understanding of the weather and its causes, without a detailed knowledge of the way in which radiation produces atmospheric circulation, and the latter, in its turn, acts back upon the radiation exchange itself.

The fundamental groundwork for such a knowledge must be obtained through observations and quantitative measurements.

The importance is stressed of measurements of the total radiation (direct + diffuse) in both clear and cloudy weather. Subtracting from this total the "effective temperature radiation of long wave length," often called "nocturnal radiation," there remains the "heat effective net radiation," which is available for "raising the temperature of soil, or water, or air, and for evaporation, melting, and other processes of transformation of water."

* * * * *

The total radiation income from sun and sky determines what we may call the illumination climate of a place, and for many purposes a measure of the former quantity gives also a sufficiently accurate measure of the natural illumination.

* * * * *

The light from sun and sky is a necessary condition for the assimilation of plants, but all the different wave-lengths have not the same effectivity. Engelman finds two bands especially effective, one in the red between 650$\mu\mu$ and 700$\mu\mu$, the other in the blue at about 480$\mu\mu$. * * * It seems probable, however, that the effectivity of different groups of wave lengths is variable from case to case, and that for different plants or in different periods of growths of the same plant the one or the other group of radiation may play the most important part.

For the first orientation we may regard the total radiation income from the sun and sky as a satisfactory relative measure of the intensity of light that is active in the processes of assimilation in nature.

* * * * *

More and more the important part played by light for the health and comfort of man is beginning to be realized. * * * In what way this light acts on the human organism is still very little known. One of the chief conditions for further development is a thorough knowledge of the quantity and quality of the stimulant under various conditions.

Chapter 1 discusses "Instruments and Principles of Measurement." Much of what is given has been published previously,[1] but improvements in both pyrheliometer and register are described and instrumental errors are discussed.

Chapter 2 gives the results of measurements. For the period April, 1926–August, 1927, hourly, daily, and monthly totals of radiation as measured on a horizontal surface are given, and also monthly means of the hourly totals. There is also given the maximum recorded intensity for each day, which the author states does not occur during perfectly clear days, but when the sun is shining between clouds which reflect the radiation they receive The highest recorded intensity is 1.725 gr.cal. per minute per square centimeter, in June, 1927.[2]

Annual and monthly totals are given for the period July, 1922–December, 1927. The average daily totals for cloudless days, and for days with the sky completely covered with clouds, have also been computed for each month. With a clear sky the highest average is 650 gr.cal. in June and the lowest 50 gr.cal. in December.

Let Q_o = the daily total radiation with a cloudless sky.
Q_s = the daily total radiation with the sky covered with clouds.
S = the ratio of the recorded hours of sunshine to the possible hours (time from sunrise to sunset).

Then Ångström finds that

$$Q_s = Q_o(0.235 + 0.765\ S)$$

[1] MONTHLY WEATHER REVIEW, 1919, 47: 795; 1921, 49: 135.

[2] The legend to Figure 21 states that the three curves give momentary maxima, mean noon, and minimum noon intensities for each month during clear days. This appears to be misleading in so far as the two last-named curves are concerned, since they seem to represent the average and the minimum values irrespective of cloudiness.

He remarks upon the significance of the close agreement between this equation and one found by the reviewer to apply to Washington, namely.

$$Q_s = Q_o(0.22 + 0.78\ S)$$

With his equation Ångström computed monthly totals for the period January, 1905–June, 1922. The annual radiation curves thus computed agree well with the curve based upon observed values. He points out, however, that the probable error of monthly totals thus computed, and especially for winter months, is large, but is small for annual totals. Annual totals thus computed have therefore been employed to show variations in the annual radiation receipt over the period 1905–1926.

From the measured monthly totals of solar radiation and computations by Westman of the total radiation received on a horizontal surface directly from the sun, Ångström has computed the percentage of the total radiation that is included in the diffuse radiation. For the year he finds it to average 30 per cent, but in different months it varies from 87 per cent in December to 19 per cent in July. For clear-sky conditions, for the year the percentage is 12.5; for December, 46; for July, 1.1; and for June 2.7 per cent. These percentages appear to be entirely too low. (See MONTHLY WEATHER REVIEW, October, 1924, 52:475, Table 1.)

The author shows that the annual variation in the total radiation receipt may be expressed by a Fourier series. He develops the series for nine stations at which records of the total radiation receipt were available to him. They vary in latitude from Stockholm, 59° 21′ N. to Lourenco Marques, 25° 58′ S.; and in altitude from 37 meters for South Kensington, England, to 1,600 meters for Davos, Switzerland. The term representing the average monthly value for the year varies from about 5,700 at South Kensington to over 12,000 at Lourenco Marques and Davos. The first periodic or average annual term varies from about 2,800 at Lourenco Marques to 7,100 at Davos, and the second periodic or semiannual term varies from 375 at Toronto to 1,360 at Davos. The maximum monthly value occurs at about the time of the summer solstice at all stations in the Northern Hemisphere, and shortly before our winter solstice in the Southern Hemisphere.

Under "Concluding Remarks" the author refers to the significance of marked departures from the normal in individual records, and suggests the following problems as of special interest:

1. Influence of different forms of clouds on the radiation exchange. Studies of the regular and diffuse reflection from clouds. Influence of clouds on different rays.
2. The records of the diffused radiation from perfectly overcast skies give possibility to follow the variations in the density and mass of clouds. A study of the relation to the synoptic situation seems desirable.
3. A study of the relation between the rapid fluctuations in radiation caused by cumulus clouds and the variations in temperature resulting herefrom.
4. Structure of clouds in the neighborhood of lines of discontinuity.
5. Studies of the diffused radiation from overcast skies for various wave lengths at the moment when rain begins to fall.

We have to thank Doctor Ångström for pointing the way in which radiation studies may be directed. As he truly states, cooperation on the part of many workers will be necessary for the complete solution of some of the problems presented. International commissions are already in existence to facilitate such cooperation.

C. E. P. BROOKS AND W. QUENNEL ON THE INFLUENCE OF ARCTIC ICE ON THE SUBSEQUENT DISTRIBUTION OF PRESSURE OVER THE EASTERN NORTH ATLANTIC AND WESTERN EUROPE [1]

By ALFRED J. HENRY

[Weather Bureau, Washington]

In a previous publication an attempt was made (2) to discover whether small changes in the temperature and volume of the Gulf Stream due to variations in the strength of the trade winds and other factors, were reflected in later changes in the pressure distribution of the eastern North Atlantic. Some definite though small effects were noted; since, however, the Gulf Stream is not the only oceanic factor that may be expected to influence the weather of the British Isles, it seemed desirable to investigate the effects which reasonably may be attributed to variations in the temperature and ice distribution in the Arctic Ocean, the Greenland Sea, and the neighborhood of Newfoundland.

Figure 1 shows the area considered, the meteorological stations whose records were utilized and a sketch of the ocean currents.

Ice appears to be formed chiefly in two parts of the north Polar Basin, viz, the area of open ocean north of Asia and the channels among the islands of the American Arctic Archipelago; the inland ice sheet of Greenland also is an important auxiliary source.

The first step in the investigation is a discussion of the tracks and average speeds of the ocean currents which carry the ice from one part in the basin to another and eventually into lower latitudes.

It has been pointed out by Wiese (3) that the greater part of the ice which finds its way into the east Greenland current is formed by the freezing of the layer of fresh water north of the mouths of the great Siberian rivers and Wiese terms this region the "factory of northern Polar ice."

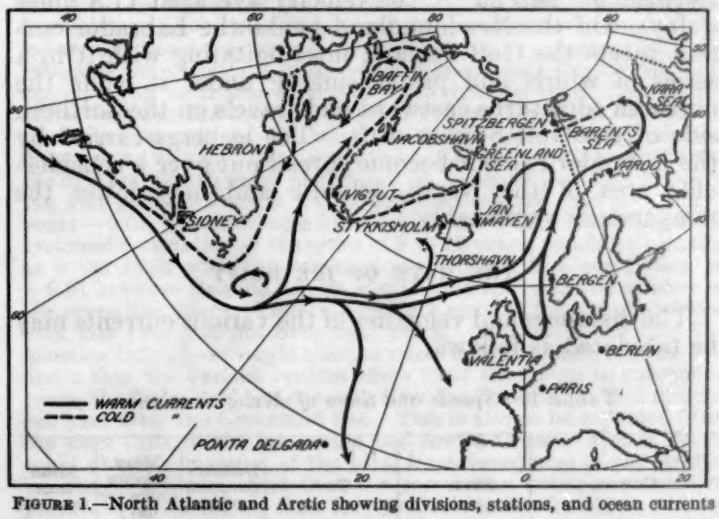

FIGURE 1.—North Atlantic and Arctic showing divisions, stations, and ocean currents

[1] Air Ministry, Meteorological Office, Geophysical Memoir No. 41 (first number of Vol. V), by C. E. P. Brooks, D. Sc., and Winifred Quennel, London, 1928. Pressure distribution over the Greenland-Iceland region is at times an important factor in determining the course followed and speed of movement of cyclones that reach northeast United States and Canada. For that reason the memoir here under review is especially welcome.—ED.

From the "factory" the ice drifts westward passing mainly south of Spitzbergen, where a great deal of ice formation goes on among the islands and continues towards the east coast of Greenland. The distance is about 2,000 miles and at the average rate of 1.2 miles per day (based on a barrel drift from Point Barrow to the north coast of Iceland) the journey would take just over four and one-half years. Wiese regards the temperature of the autumn, months of September to November, at Obdorsk and Touroukhansk in northern Siberia as the best available criterion of the ice-forming activity in the "factory" (a low temperature giving much ice and a high temperature little ice) and he finds that the correlation coefficient between the mean of the autumn temperatures at those places (1877–1910) and the ice-covered area in the Greenland Sea four and one-half years later has the high value of -0.83 ± 0.05 which he regards as confirmation of the theory. Sir Gilbert Walker has informed the authors, however, that there is an equally high correlation between the Greenland Sea ice and the conditions in the "factory" three months later, and that the connection found by Wiese may be dependent upon the remarkable periodicity of four and three-fourths years in the Greenland Sea and Iceland conditions to be referred to later.

THE LABRADOR CURRENT

The main mass of the Arctic water follows the coast of Greenland, bearing great quantities of ice. This current moves with a velocity of 5 to 10 miles a day and is banked up against the coast by the earth's rotation so that there is very little scattering. Rounding Cape Farewell the current passes up the west coast of Greenland as far as Disco Island, picking up icebergs from the Greenland ice sheet on its way. Under the influence of easterly winds caused by the secondary barometric minimum in Davis Strait, the current turns to the westward and then southward along Baffin Land, receiving tributary currents from the channels between the islands of the North American Archipelago and from the Arctic Ocean by way of Smith, Jones, and Lancaster Sounds. This is the beginning of the Labrador current; between 74° and 69° N. the velocity was found by Hall's Polar Expedition to be 6.3 miles a day, but this may have been in a weak part of the current. Between 69° and 53° N. the velocity averaged 11.8 miles a day. Off the Newfoundland banks the Labrador current meets the Gulf Stream, interdigitating with it in a series of whirls and partly sinking under it while the northern edge turns eastward and travels on the northern side of the Gulf Stream drift. The icebergs carried by the Labrador current become spread out over a considerable area of the North Atlantic and may lower the temperature appreciably.

THE RATE OF ICE DRIFT

The distances and velocities of the various currents may be tabulated as follows:

TABLE 1.—*Speeds and times of Arctic circulation*

Current	From—	To—	Distance (nautical miles)	Mean velocity (miles per day)	Mean time (months)
Arctic Ocean drift	75° N., 75° W.	75° N., 0°	2,000	1.2	55
Greenland current	75° N., 0°	69° N., 53° W.	2,150	7.5	10
Labrador current	69° N.	47° N., 55° W.	1,600	12	4
Gulf Stream drift	47° N., 55° W.	60° N., 5° W.	1,800	12	5

The distances and velocities as given above are, of course, only the roughest approximations but they will serve to give an idea of the time required for variations in the ice conditions in one part of the Arctic to be propogated along the currents and thus affect the conditions in other parts.

THE PALÆOCRYSTIC ICE

The areas for which ice data are available—Greenland Sea, Barents Sea, and Kara Sea—(see fig. 1), include only the fringe of the great ice area of the Arctic Ocean, which persists from one year to another and has been termed palæocrystic ice. The fringe is important in supplying the scattered ice which reaches Iceland or rounds Cape Farewell, and the cold thaw water which probably has an appreciable effect on the temperature of the cocean between Greenland and Scandinavia, but the main ice mass would be expected to play a greater part in causing variations in the general atmospheric circulation of the globe. Unfortunately there are no measurements of the whole ice-covered area, but results obtained by other authors show that even indirect measures may have considerable significance. The authors conclude that one of the objects of this study must be to devise some numerical index which can be employed as a measure of the area of Paleochrystic Ice. (See Table 2 (original Table XXIII).)

THE GREENLAND SEA AND ICELAND REGION

The effect of variations in the ice conditions in the Greenland Sea and off Iceland has been studied by W. Wiese (**4**), W. Brennecke (**5**), and W. Meinardus (**7**). Wiese found that years with heavy ice in the Greenland Sea in spring and summer (April–July) were characterized in autumn (September to November) by a higher pressure in the neighborhood of Iceland, Greenland, and the White Sea, and a lower pressure over the British Isles. This distribution is associated with a southerly movement of the tracks of depressions. Brennicke investigated the variations of ice off Iceland and found that years with little ice tend to be associated with an abnormally large pressure difference between Iceland and Scandinavia in spring (March to May), while years with much ice tend to be associated with a small pressure difference between Iceland and Scandinavia. Thus, generally speaking in the spring of ice-poor years pressure is abnormally low in Iceland and high in Scandinavia, in ice-rich years high in Iceland and low in Scandinavia.

A similar result as regards pressure in Iceland was given by a study of the deviation of pressure from normal at Stykkisholm, during the presence of ice, days with the presence of ice off Iceland, had pressure that averaged 6.7 mb. above the mean pressure for the corresponding months (**6**). Meinardus, also investigated the variations of ice in the neighborhood of Iceland. He pointed out that there was a very clearly marked periodicity of four and one-half years; a further investigation shows that this period is more nearly four and three-fourths years (**8**).

In the second part of his work Meinardus investigates the cause of these variations. He points out that the quantity of ice in the east Greenland current is least in autumn when the eastern boundary of the ice is so near the Greenland coast that Iceland is almost invariably quite clear of ice. But the advancing masses of Polar ice are already beginning to reach the northern part of the Greenland Sea by the end of summer. The beginning of the ice season at Iceland is determined by the arrival of this swelling in Denmark Strait, but in many years the

amount of ice is insufficient to fill the strait and Iceland remains free. In normal years the ice reaches its maximum in April and May. C. E. P. Brooks investigated the 4¾-year periodicity in Iceland ice but without significant results.

SUMMARY OF PART I

The preceding discussion has shown that at least three effects have to be considered:

(*a*) The effect of variations in the ice-covered area in the Arctic basin on the general circulation of the globe.

(*b*) The effect of variations in the ice-covered areas in the Greenland Sea and near Iceland on the pressure distribution over the North Atlantic Ocean and western Europe.

(*c*) The effect of variations in the supply of ice and cold water introduced into the North Atlantic by the Labrador current.

PART II. THE EFFECT OF ARCTIC ICE

In this part of the memoir the effect of the variates named below is investigated by means of correlation coefficients. The variates are as follows:

(*a*) The duration and severity of the ice off Iceland.
(*b*) Temperature at Stykkisholm (as a check on (*a*)).
(*c*) The pressure difference, Stykkisholm minus Vardo in November to January.
(*d*) The area of ice in the Greenland Sea.
(*e*) Temperature at Jan Mayen (as a check on (*d*)).
(*f*) The area of ice in Barents Sea.
(*g*) The area of ice in Kara Sea.
(*h*) The temperature of Obdorsk and Touroukhansk in September to November.
(*k*) Pressure and temperature at Spitsbergen.

The correlation coefficients among the variates given above are set forth in a series of tables, Nos. II to XIX, and these are followed by a consideration of partial correlation coefficients as indicated in section 21 as follows:

The preceding discussion has brought out two periods in which pressure in western Europe and the North Atlantic probably has real relationships with ice conditions in the Arctic, viz, April to June contemporaneous with the ice, and the following November to January. In order to examine these relationships more closely, partial correlations were calculated between the ice conditions in the four centers—Iceland, December to June, Greenland Sea (April to June), Barents Sea (April to June), and Kara Sea (August) on the one hand, and the four stations, Stykkisholm, Vardo, Valentia, and Ponta Delgada, on the other hand.

The crude correlation coefficients between the different ice data are shown in the table below:

Ice	Greenland Sea	Barents Sea	Kara Sea
Iceland	+0.43	+0.32	+0.25
Greenland Sea		+.20	+.32
Barents Sea			+.28

The discussion in sections 22 and 23 is reproduced verbatim.

THE ANNUAL VARIATION OF THE EFFECTS OF ARCTIC ICE

In sections 15 and 16 we found evidence that the effects of a heavy or light ice season persist for several years, but go through an annual variation so that they differ in different seasons. There are indications of this annual variation in the case of the Greenland Sea ice, the positive coefficients with pressure in July to September of the same year recurring in the same months of the following year, and the same recurrence is indicated with Iceland ice, especially by the figures for 1902 to 1923. We may take Stykkisholm as typical of the northern stations; here the general sequence is: Positive coefficients in July to September, small coefficients in October to December, negative coefficients in January to March, and small negative coefficients in April to June. There are two problems here, first the change from positive to negative, and secondly the repetition in successive years.

The annual variation of the coefficients may plausibly be referred to the annual variation of three other quantities:

(1) The area and solidity of the Arctic ice, which reaches a maximum in January to March and a minimum in July to September. As there is a high correlation between the area of ice in, say, the Barents Sea in April to August of one year and in the same months of the following year, it is a plausible assumption that there is also a high correlation between the area of ice in summer and that in the following winter.

(2) The intensity of the Icelandic minimum of pressure which is greatest in winter and least in summer.

(3) The cooling of the surface waters of the North Atlantic by thaw water from the ice in the east Greenland current, which is greatest in summer, and is practically negligible in winter. The main reason for this is that in these regions very little scattering and melting of ice takes place in winter, but a great deal in summer. A secondary factor is the annual variation of the Gulf Stream drift toward the Arctic Ocean, which owing to the annual variation in the direction and velocity of the winds, is strongest and most regular in winter, weakest and least regular in summer.

In section 19 it was suggested that there are two opposing tendencies in the effect of Arctic ice on pressure at Stykkisholm, namely: (*a*) A tendency for a large temperature difference between the Equator and the North Pole to bring about a dynamic intensification of the Icelandic low, and (*b*) a tendency for much ice to give high pressure owing to the direct effect of the cold surface on air temperature and density. With this latter tendency we may include the effect of the Gulf Stream drift referred to under (3) above, a weakening of the Gulf Stream being presumed to have the same effect as an increase in the area of ice. Not only are (1) the area and solidity of the Arctic ice cap greatest in January to March, but the cooling power of ice on the air above it also appears to be greatest in winter. Hence it is reasonable to suppose that the effect of this ice cap on the general atmospheric circulation is greatest about January to March and least about July to September. The relation between (2) the general circulation of the atmosphere and pressure in the Icelandic low should be closest when that low is best developed; i. e., in winter. Both (1) and (2) would therefore lead us to anticipate a stronger tendency in winter than in summer for negative correlation between the area of Arctic ice and pressure at Stykkisholm, (3) the cooling of the surface of the North Atlantic near Iceland by thaw water being greatest in summer, we should expect the cooling of the overlying air, and consequently the direct rise of pressure near Iceland, to be greatest at this season. This would give a tendency for positive correlation between the area of ice and the pressure at Stykkisholm in summer but not in winter. The annual variation actually found would then represent the balance between factors (1) and (2) on the one hand and factor (3) on the other hand. The annual variations of the coefficients at the remaining stations—Valentia, Berlin, and Ponta Delgada—are less marked and may be regarded as mainly secondary effects due to the dynamical relations of pressures at these stations with those in Iceland and the Arctic.

The second problem is the persistence of similar coefficients at the same seasons over a period of several years. The Barents Sea and the Kara Sea are on the fringe of the great mass of palæocrystic ice which persists year after year. Hence the variations of the ice area in these seas may be regarded as to some extent an indication of the variations in the main mass of palæocrystic ice, and consequently as rather persistent from year to year. The correlation between the areas of Barents Sea ice (April to August) in successive years is +0.57; hence we should expect the correlation between the first and third years to be $(0.57)^2$ or 0.32, and between the first and fourth years $(0.57)^3$ or 0.19. Actually we find between the first and third years +0.22 and between the first and fourth years −0.01, the differences from +0.32 and +0.19 indicating some systematic variation of the order of 8 to 12 years, which we identify as a variation with the sun-spot cycle (there is a correlation of −0.51 between Barents Sea ice and the sun spot relative number of the preceding year). These coefficients account for the persistence over one year but not over four years. Without going into the question fully, however, it may be remarked that there is some evidence that the various centers reach their maximum in successive years, the Greenland Sea one year after the Barents Sea and Iceland one year after the Greenland Sea. This is also to be expected from the slow drift of the ice across the Arctic Ocean. Hence, if we could obtain a measure of the total ice-covered area of the Arctic, we should probably find that the correlation between successive years was much higher than for the Barents Sea ice alone.

THE INDEX OF ARCTIC ICE

A measure of the total ice-covered area is at present outside practical politics, we have to do the best we can with the data

for the fringe of the ice which are actually available. Here we are faced with the difficulty that the ice conditions at Iceland and in the Greenland Sea, which are nearest to the western European region, have the greatest temporary effect on pressure there, but being outposts, are probably less representative of the persistent conditions of the central Arctic Ocean than are the Barents and Kara Seas. After some discussion, taking as a basis the partial correlation coefficients in Tables XX–XXII, we arrived at the following expression for a figure which we call the index figure of Arctic ice:

5 [Greenland Sea ice, April to August]+7 [Barents Sea ice, April to August] +2 [3 (Kara Sea ice, August)+Kara Sea ice, April to August].

The values of the "ice index" obtained in this way are given in Table XXIII.

TABLE 2 (ORIGINAL XXIII).—*Values of "ice index" for Arctic Ocean*

	0	1	2	3	4	5	6	7	8	9
1890						115	111	101	81	101
1900	97	104	127	113	89	107	105	107	103	119
1910	112	123	135	125	116	114	133	145	137	112
1920	101	104	86	94	88					

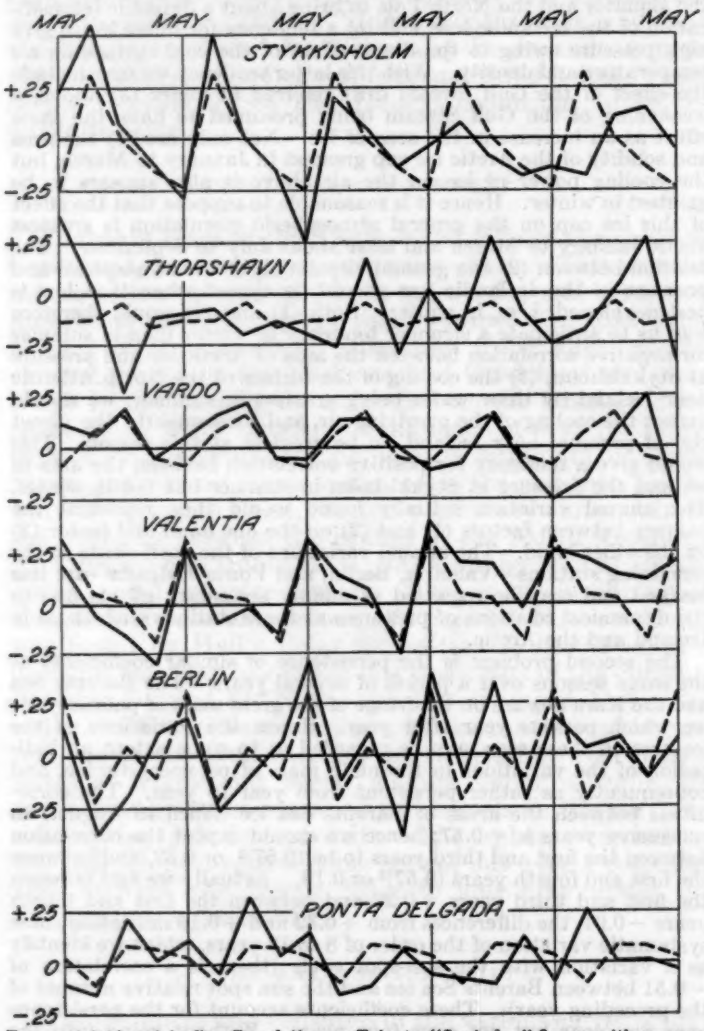

FIGURE 2 (14 in original).—Correlation coefficients, "Ice index" figures with pressure in succeeding years. Broken lines represent the average coefficients for the first four years.

For convenience of workers wishing to utilize these figures for obtaining other correlation coefficients it may be remarked that their variance[17] is approximately 20.

The correlation of the "ice index" for one year with that of the next gives a coefficient of +0.66, appreciably higher than that for the Barents Sea ice alone.

These figures were then correlated with the means of pressure for each quarter from April to June of the same year to April to June five years later. The results are shown in Figure 2. The coefficients for Stykkisholm, Vardo, and Valentia show the annual variation very clearly, those for Berlin and Ponta Delgada less clearly, Thorshavn not at all.

CONCLUSIONS

The general result of this investigation of the effect of ice conditions on subsequent pressure in the eastern North Atlantic and western Europe is that Arctic ice is an appreciable factor in the weather of the British Isles. Much ice in the spring and summer tends to be associated with high pressure in the same months at the northwestern stations Jacobshavn, Stykkisholm, and Thorshavn, and with low pressure at the southern stations, Paris and Ponta Delgada, the relationships being shown by well-supported correlation coefficients which range up to 0.5. Again, much ice in spring or summer tends to be followed in November to January by low pressure over the British Isles, this relation being very definite and regular whatever index of Arctic ice conditions is employed. The ice conditions in various parts of the Arctic have been combined into a series of "ice index" figures, which have the following well-supported correlation coefficients with pressure in the following November to January: Ponta Delgada, −.35; Stykkisholm, +.27; Ponta Delgada minus Stykkisholm, −.37. These relationships appear to recur in the following two years, thus giving rise to a rather regular annual variation of the correlation coefficients. At Stykkisholm and Valentia the effect of Arctic ice on the pressure appears to outweigh the effect of the warm Gulf Stream very considerably, but at Ponta Delgada the latter is the more important factor. The effect of the ice off Newfoundland on pressure over western Europe is generally similar to that of Arctic ice, but is much less pronounced.

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[17] See: Walker, Sir Gilbert, and E. W. Bliss "On Correlation Coefficients, their Calculation and Use." London, Q. J. R. Meteor. Soc., 52, 926, p. 73.

NOTES, ABSTRACTS, AND REVIEWS

Weather reports by teletype to airports.—Regular twice daily weather reports from practically all stations in the United States, Canada and Alaska, including upper-air data from about 20 aerological stations, are now being retransmitted morning and night by teletype printers direct from the Weather Bureau at Washington to the airports at Hadley Field, N. J., Bellefonte, Pa., and Cleveland, Ohio, on the eastern sector of the transcontinental airway. This new service was inaugurated on the night of February 6, 1929, as an addition to the program of weather information already made available to aviators and others along this air route.

Under present arrangements, transmission of these reports begins promptly at 8:15 o'clock a. m. and p. m. and continues for 20 minutes. There is then a break of 25 minutes for exchange of reports between the airway stations themselves and for other necessary traffic over the wire. At 9 o'clock the sending of weather reports from Washington is resumed, and continues until all have been sent, which is, as a rule, not later than 9:25 o'clock. The reports are sent at a uniform rate of about 40 words a minute, and are received in typewritten form on tape at the airways.

Formerly, only a limited number of reports were furnished the airports in question by radio. The new method makes it possible for the airports to receive a far more complete list of reports, and much more promptly.

At Hadley Field and Cleveland these reports are charted and used in connection with detailed advices and weather information furnished to the fliers. Copies of the map are posted also and made accessible to air mail and commercial pilots.

In addition to those at Hadley Field, Cleveland, and Washington, teletype printers, with apparatus for both sending and receiving, are also located along the airway at Mercer, Brookville, Kylertown and Northampton, Pa., with the prospect that other landing fields will be similarly equipped from time to time. All machines in the system are connected by a leased wire, which carries in addition to the weather reports from Washington and necessary messages from field to field, hourly reports of weather and landing conditions at each point. At the end of each hour a summary of these conditions and, when necessary, a statement regarding expected changes in weather is prepared at Cleveland, and distributed by the teletype system.

Symposium on nomenclature of cyclones and anticyclones.—The second half of the Weather Bureau staff meeting of April 17, 1929, was devoted to a discussion of the nomenclature of cyclones and anticyclones in the very special sense of the expressions "secondary" cyclones and "secondary" anticyclones. The object of the discussion was first to determine whether practice in the Weather Bureau is uniform respecting the expression "secondary" cyclone and second, to clearly define the differences in structure and behavior, if any, between the so-called secondary and primary cyclones.

The consensus of view with respect to the first was that the definition of the "secondary" originally laid down by Abercromby,[1] agrees closely in principle with that held by members of the Weather Bureau staff.

It developed in the discussion that one form of barometric depression—viz, a small cyclone within a greater one, which in Great Britain is classed as a secondary—is rarely observed on the weather charts of the Western Hemisphere. The discussion also showed almost complete unanimity in the opinion that there are no essential differences either in form or behavior of the two groups commonly known as primary and secondary cyclones. The expression "secondary" anticyclone found few supporters.—*A. J. H.*

Remarkable clouds at high altitudes[2] (condensed from Nature, London, February 16, 1929).—Prof. Carl Stormer, who has given us such splendid photographs of the aurora borealis has observed and photographed specimens of the noctilucent clouds that were so much in evidence after the volcanic eruption of Krakatoa some forty-odd years ago. Professor Stormer observed and photographed these clouds in December, 1926, and again in January 13, 1929. On the last-named date he was so fortunate as to have his two aurora stations of Oslo and Oscarborg in operation immediately after sunset, and was thereby able to secure more than 90 simultaneous photographs. The material thus secured is unique in the history of the observation of noctilucent clouds and he was able to calculate their height from abundant and trustworthy material. The altitude of these clouds as thus determined was about 25 kilometers; some were a little greater and some a little less.—*A. J. H.*

New equipment for Observatorio del Salto, Santiago, Chile (by J. Bustos Navarrete, director).—The Observatorio del Salto has just received a spectroactinometer for measuring the intensity of luminous and ultra-violet solar radiation. The measurements will be made by means of photoelectric cells and an electrometer.

The variations of the three spectral regions, thermic (infra-red), luminous and ultra-violet, are in close relation to one another. In general, an increase in the total radiation is accompanied by a marked increase in the ultra-violet, while a decrease in the total is accompanied by a relative increase in the infra-red.

Owing to the sensitiveness of the instrument, it will be possible to detect slight variations in the total solar radiation, since radiation in narrow spectral bands may be extrapolated to zero air mass with small error, and from the variations in these bands the variation in the total may be inferred.

Meteorological summary for Chile, February, 1929 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—Atmospheric circulation was characterized by moderateness. Scattered rains fell in the south between Concepcion and Magallanes, while in the central there was somewhat more precipitation than in January.

The most important depressions that were attended by unsettled weather and rain were those charted in the following periods: 3d, 5th–6th, 9th–12th, and 20th. All of these depressions crossed the extreme south.

The only anticyclonic center worthy of mention was that of the 13th–15th, dominating conditions in the extreme southern region. In consequence of the marked difference in pressure established between that region and the central zone there developed on the following days, until the 17th, violent south winds on the coast.

In comparison with the preceding month February was not so warm in the central zone and not so rainy in the southern zone.—*Translated by W. W. R.*

[1] Principles of Weather Forecasting, p. 23.

[2] Cf. Noctilucent clouds and unpublished measurements of their velocity ,b Archenhold. This REVIEW 56: 278–80.

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SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS MADE DURING MARCH, 1929

By HERBERT H. KIMBALL

For references to descriptions of instruments and exposures, and to an account of the method of obtaining and reducing the measurements, the reader is referred to this volume of the REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged above normal values for March at Washington and below normal values at Madison and Lincoln.

Table 2 shows an excess in the total radiation received on a horizontal surface at Chicago, and a deficiency at Washington, Madison, and Lincoln.

Skylight polarization measurements obtained on five days at Washington give a mean of 62 per cent with a maximum of 68 per cent on the 29th. These are above the corresponding averages for March at Washington. At Madison measurements obtained on the 28th gave 73 for the percentage of skylight polarization, which is considerably above the average for that station in March.

TABLE 1.—*Solar radiation intensities during March, 1929*

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M. 5.0	4.0	3.0	2.0	[1] 1.0	P. M. 2.0	3.0	4.0	5.0	Local mean solar time
	e.	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e.
Washington, D. C.	*mm.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm.*
Mar. 1	4.17				1.02						3.45
Mar. 3	3.15				1.28	1.55	1.27	1.07	0.86	0.72	3.00
Mar. 6	2.62	0.87	0.93	1.15	1.35		1.17				2.87
Mar. 7	1.52	0.98	1.08	1.20	1.34	1.49					2.06
Mar. 8	1.37	0.69	0.85	1.01	1.13	1.30					1.60
Mar. 11	2.36						1.41	1.10	1.00	0.85	2.87
Mar. 16	7.87			1.05	1.25						6.27
Mar. 18	2.87	0.87	0.92	1.07	1.19	1.45	1.26	0.98	0.88	0.77	2.87
Mar. 24	9.87					1.19					11.81
Mar. 26	12.68				0.95						10.59
Mar. 27	4.57		0.88	0.99	1.19	1.44					4.17
Mar. 29	3.45			1.18	1.38	1.47					2.62
Means		0.85	0.93	1.09	1.21	1.41	1.28	1.05	0.91	0.78	
Departures		+0.12	+0.12	+0.14	+0.06	−0.02	+0.15	+0.11	+0.11	+0.08	
Madison, Wis.											
Mar. 5	1.96	0.87	0.94	1.07	1.27	1.53					2.74
Mar. 7	0.91		1.10	1.25	1.41	1.59	1.41				1.45
Mar. 9	1.07			1.28	1.42	1.57	1.42				1.19
Mar. 14	5.79						1.13				7.87
Mar. 18	4.57		0.88	0.97	1.11		1.16				4.57
Mar. 26	3.63				1.15	1.46					3.30
Mar. 27	4.39						1.06				3.45
Mar. 28	4.17	0.96	1.07	1.19	1.33	1.55	1.26				3.00
Means		(0.92)	1.00	1.15	1.28	1.54	1.24				
Departures		−0.06	−0.04	−0.03	−0.03		−0.05				
Lincoln, Nebr.											
Mar. 5	3.63			1.10							4.75
Mar. 6	4.17		0.86	0.96	1.25						3.45
Mar. 7	2.62	0.86	1.01	1.16							2.87
Mar. 13	4.37			1.00	1.16	1.37	1.27	1.05	0.90	0.75	3.81
Mar. 14	3.63	0.58	0.71	0.99	1.14						4.17
Mar. 16	4.17		1.00	1.15	1.31	1.49		1.11	1.01	0.92	4.37
Mar. 17	3.81						1.25	1.11	0.94	0.84	4.17
Mar. 19	4.17				1.40						3.30
Mar. 26	3.45						1.21	1.08	0.75	0.56	2.36
Means		(0.72)	0.90	1.06	1.25	(1.43)	1.24	1.09	0.90	0.77	
Departures		−0.13	−0.05	−0.03	−0.04		0.04	+0.00	−0.04	−0.05	

[1] Extrapolated.

TABLE 2.—*Total solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning—	Average daily radiation: Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Fresno	Average daily departure from normal: Washington	Madison	Lincoln	Chicago	New York
1929	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Feb. 26	166	216	291	190	.....	.....	428	−121	−70	−53	+1	.....
Mar. 5	414	307	396	259	.....	.....	329	+94	+13	+43	+63	.....
Mar. 12	277	294	356	230	.....	.....	388	−49	−28	−18	+22	.....
Mar. 19	313	202	349	194	.....	.....	459	−44	−125	−57	−28	.....
Mar. 26	348	399	352	260	.....	.....	563	−2	+36	−51	+24	.....
Excess or deficiency since first of year on Apr. 2								+91	−1,015	−2,828	+973	.....

POSITIONS AND AREAS OF SUN SPOTS

Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic: Diff. long.	Longitude	Latitude	Area: Spot	Group	Total area for each day
1929	*h. m.*	°	°	°			
Mar. 1 (Naval Observatory)	11 50	−83.5	129.4	−10.0	247	.....	.....
		−6.0	206.9	−10.0	.....	15	.....
		+7.0	219.9	−8.5	93	.....	.....
		+26.0	238.9	+7.0	.....	108	.....
		+33.5	246.4	−14.5	9	.....	472
Mar. 2 (Yerkes)	12 36	−80.3	119.0	−8.8	.....	100	.....
		−74.4	124.9	−7.2	.....	250	.....
		−69.4	129.9	−9.7	.....	100	.....
		+20.8	220.1	−9.7	.....	75	525
Mar. 3 (Naval Observatory.)	11 41	−64.0	122.6	−7.5	.....	525	.....
		−56.5	130.1	−10.0	154	.....	.....
		+34.5	221.1	−8.5	31	.....	.....
		+35.5	222.1	+15.0	.....	46	.....
		+51.0	237.6	+7.5	.....	108	864
Mar. 4 (Harvard)	10 43	−77.5	96.5	−9.0	.....	550	.....
		−47.0	127.0	−8.0	.....	673	.....
		+48.5	222.5	−9.5	24	.....	.....
		+51.5	225.5	+15.5	.....	78	.....
		+66.0	240.0	+7.0	.....	80	1,405
Mar. 5 (Yerkes)	10 2	−78.0	83.2	−10.2	.....	400	.....
		−72.7	88.5	−8.1	.....	75	.....
		−67.8	93.4	−10.1	.....	600	.....
		−67.7	93.5	−7.8	.....	150	.....
		−43.5	117.7	−8.1	.....	50	.....
		−35.7	125.5	−7.1	.....	300	.....
		−31.5	129.7	−9.9	.....	60	.....
		+64.4	225.6	+15.4	.....	100	1,735
Mar. 6 (Naval Observatory)	11 59	−62.0	84.9	−3.5	31	.....	.....
		56.5	90.4	−10.0	.....	648	.....
		−23.0	123.9	−7.0	.....	309	.....
		−17.5	129.4	−10.0	.....	77	.....
		−9.5	137.4	−15.5	.....	31	.....
		+73.5	220.4	−8.5	6	.....	.....
		+78.0	224.9	+16.0	.....	139	1,241
Mar. 7 (Naval Observatory)	11 57	−78.5	55.3	+7.5	93	.....	.....
		−42.5	91.3	−9.5	.....	756	.....
		−9.0	124.8	−7.0	.....	278	.....
		−5.5	128.3	−10.5	.....	77	.....
		+3.5	137.3	−15.5	.....	25	.....
		+44.5	178.3	+15.5	.....	46	1,275
Mar. 8 (Naval Observatory)	11 38	−66.0	54.8	+7.5	62	.....	.....
		−28.0	92.8	−9.5	.....	756	.....
		+5.0	125.8	−7.0	.....	401	.....
		+19.0	139.8	−15.5	12	.....	.....
		+60.5	181.3	+15.5	46	.....	1,277
Mar. 9 (Naval Observatory)	12 26	−62.5	44.7	+23.0	.....	77	.....
		−52.5	54.7	+7.5	.....	46	.....
		−13.5	93.7	−9.0	.....	648	.....
		+19.0	126.2	−8.5	.....	401	1,172
Mar. 10 (Naval Observatory)	11 47	−62.0	32.3	−7.0	.....	93	.....
		−50.5	43.8	+23.0	.....	62	.....
		−39.5	54.8	+7.5	31	.....	.....
		−0.5	93.8	−9.0	.....	679	.....
		+32.0	126.3	−8.0	.....	355	1,220

POSITIONS AND AREAS OF SUN SPOTS—Continued

Date	Eastern standard civil time	Heliographic			Area		Total area for each day
		Diff. long.	Longitude	Latitude	Spot	Group	
1929	h. m.	°	°	°			
Mar. 11 (Naval Observatory).	11 42	−58.0	23.2	−13.5	22		
		−50.0	31.2	−7.5		170	
		−37.5	43.7	+22.5		46	
		−26.0	55.2	+7.0	25		
		+12.5	93.7	−9.0		802	
		+45.0	126.2	−7.5		262	1,327
Mar. 12 (Naval Observatory).	11 55	−44.5	23.4	−13.5	12		
		−35.5	32.4	−7.0		201	
		−25.0	42.9	+23.5		77	
		−12.5	55.4	+7.0	9		
		+25.5	93.4	−9.0		802	
		+27.0	94.9	+17.5		6	
		+59.0	126.9	−7.5		247	1,354
Mar. 13 (Harvard)	13 9	−28.0	26.0	−14.0	17		
		−18.5	35.5	−7.0		150	
		+42.0	96.0	−8.0		1,043	
		+74.5	128.5	−6.0		310	1,529
Mar. 14 (Yerkes)	10 25	−14.5	27.8	−7.5		50	
		−2.8	39.5	−8.3		50	
		+52.3	94.6	−9.6		800	900
Mar. 15 (Mount Wilson)	11 20	−80.0	308.7	+8.0	355		
		+7.0	35.7	−8.0		60	
		+23.0	51.7	+7.0	3		
		+42.0	70.7	−14.0		28	
		+66.0	94.7	−9.0		984	1,430
Mar. 16 (Naval Observatory).	11 46	−70.5	304.8	+9.5		432	
		+7.5	22.8	−15.0	6		
		+21.0	36.3	−7.5		31	
		+37.5	52.8	+7.5	15		
		+55.5	70.8	−13.5		93	
		+80.5	95.8	−9.0		540	1,117
Mar. 17 (Naval Observatory).	11 39	−57.0	305.2	+9.5		417	
		+69.0	71.2	−14.0		93	510
Mar. 18 (Naval Observatory).	11 43	−43.0	305.9	+9.5		309	
		+80.0	68.9	−15.0	46		355
Mar. 19 (Naval Observatory).	12 41	−27.0	308.2	+9.5		293	293
Mar. 20 (Naval Observatory).	11 28	−13.5	309.2	+9.5		293	293
Mar. 21 (Naval Observatory).	11 45	+0.5	309.9	+9.0		247	247
Mar. 22 (Harvard)	10 50	+15.0	312.0	+8.0	394		394
Mar. 23 (Yerkes)	9 47	+26.6	310.7	+7.8		300	300
Mar. 24 (Naval Observatory).	11 12	−53.5	216.6	−12.5		123	
		+40.5	310.6	+9.0		170	293
Mar. 25 (Naval Observatory).	14 25	−38.0	217.2	−12.5		139	
		+56.5	311.7	+8.5	170		309
Mar. 26 (Naval Observatory).	11 5	−26.5	217.3	−12.5		170	
		−1.0	242.8	−5.5	6		
		+68.0	311.8	+8.5	185		361
Mar. 27 (Naval Observatory).	11 32	−12.0	218.4	−12.5		170	
		+11.0	241.4	−5.0		37	
		+82.0	312.4	+8.5	170		377
Mar. 28 (Naval Observatory).	11 55	+2.0	219.0	−12.5		201	201
Mar. 29 (Naval Observatory).	11 45	+16.5	220.4	−12.5		185	185
Mar. 30 (Yerkes)	9 20	+23.6	215.7	+9.9		75	
		+26.7	218.8	+9.8		100	
		+28.9	221.0	−13.4		75	250
Mar. 31 (Harvard)	12 20	−79.5	97.5	−10.5		472	
		−54.5	122.5	−3.0		52	
		+42.0	219.0	+10.5		231	
		+45.0	222.0	−13.5		90	845
Mean daily area for March							776

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR MARCH, 1929

[Data furnished through the courtesy of Prof. W. Brunner, University of Zurich, Switzerland]

March, 1929	Relative numbers	March, 1929	Relative numbers	March, 1929	Relative numbers
1	[4] 44	11	E [2 5] 92	21	[2] 11
2	47	12	94	22	
3	W [3] 59	13	77	23	E [5] ?
4		14	66	24	
5	53	15	W [1 4 3] 65	25	22
6	73	16	58	26	35
7	74	17	40	27	39
8	[3] 90	18	24	28	[1] 18
9	103	19	19	29	W [3] 20
10	[3] 91	20	15	30	40
				31	55

Mean, 27 days: 52.7.

[1] Passage of an average-sized group through the central meridian.
[2] Passage of a large group through the central meridian.
[3] New formation of a larger or average-sized center of activity; E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
[4] Entrance of a larger group on the east limb.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Beginning this month certain intermediate levels are omitted from Tables 1 and 2 and the wind resultants shown in Table 2 are based on pilot-balloon instead of kite observations. The number of stations shown in this table has been increased.

Table 1 shows a rather striking temperature relationship for the month in that the departures are all positive in the lower levels and negative in the upper levels, the latter increasing appreciably at the highest level, 4,000 meters. In view of this abnormally cold air aloft surmounting abnormally warm air it might be expected that conditions were exceptionally favorable for precipitation. However, with the negative relative humidity departures occurring coincidently with negative temperature departures there was no appreciable excess in the monthly precipitation except at Due West, where the total was 10.94 inches. At this station however, the negative temperature departures were smallest.

Vapor pressure departures were positive in the lowest levels and negative above.

Resultant winds for the month were light and variable at the surface and lower levels (see Table 2). At 1,000 meters the directions were mostly westerly and the velocities about 5 m. p. s. At 4,000 meters, the westerly component is pronounced and the velocities range mostly between 10 and 15 m. p. s.

A sudden drop of 4° C. in the surface temperature occurred shortly after 8 a. m. on the 14th at Due West coincidently with a moderately heavy shower. A kite flight extending to a little more than 1,000 meters above the surface had just ended and this showed an unusually high lapse rate (0.66° C.) for this time of day for the first 500 meters. Although the rain continued throughout the day and night, another kite flight was made at 2 p. m. of the 14th which reached to 2,588 meters (M. S. L.). This flight was of particular interest in that it showed an inversion throughout the first 500 meters, practically an adiabatic lapse rate (0.91° C.) for the next 800 meters, and 0.84° C. throughout the remaining 1,000 meters.

Surface temperature inversions in the midafternoon are extremely rare and in this case the cause was obviously a cooling of the surface air as a result of the rain, while the air at 500 meters was actually warmer in the afternoon than in the morning, due to the continuous southerly winds which prevailed in the front sector of the LOW. A flight made in the early afternoon of the same day (14th) at Royal Center under the influence of a LOW centered to the north showed an unusually strong lapse rate (0.86° C.) from the surface to the maximum altitude (2,616 meters). However, with the relative humidities around 60 per cent there was no precipitation and only about 5/10 Cu. clouds.

A kite flight on the morning of the 12th at Groesbeck was made during the passage of a wind-shift line. The record shows the greatest fall in temperature during the flight (5.3° C.) to be at 1,500 meters whereas the surface temperature had fallen only 3° C. during the same interval (45 minutes).

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during March, 1929*

TEMPERATURE (°C.)

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		Washington, D. C.[1] (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Meters												
Surface	10.5	+0.5	13.0	+0.9	−0.1	+1.9	13.2	−0.1	6.9	+2.6	12.6	+5.0
500	2.6	+1.2	12.0	+1.6	−0.4	+1.8	12.7	+0.6	4.5	+2.2	10.8	+4.6
1,000	8.7	+1.2	9.7	+0.6	−0.6	+2.1	11.8	+0.4	2.8	+1.3	9.1	+4.1
1,500	6.3	−0.3	7.5	−0.3	−1.3	+2.0	10.4	−0.3	1.0	+0.3	6.2	+2.7
2,000	4.1	−0.7	5.3	−0.3	−4.1	+1.0	8.0	−1.2	−1.6	−0.6	3.0	+1.7
2,500	1.3	−1.2	2.8	−0.5	−7.6	−0.1	5.5	−1.5	−4.5	−1.2	0.2	+1.1
3,000	−1.0	−1.0	1.3	+0.2	−10.8	−0.5	3.2	−1.2	−7.1	−1.4	−2.6	+0.8
4,000	−6.4	−3.4	−3.8	−1.9	−16.8	−3.7	------	------	−13.1	−4.7	−9.5	−2.7

RELATIVE HUMIDITY (%)

Surface	65	+1	66	+2	77	+4	82	+11	72	+1	68	+2
500	61	−1	57	−5	77	+5	71	+3	74	+4	63	−7
1,000	51	−9	55	−6	65	−3	58	−6	68	+2	56	−2
1,500	48	−8	52	−8	59	−7	42	−17	60	−2	55	−7
2,000	46	−4	49	−7	57	−7	38	−13	57	−2	54	−4
2,500	45	−1	46	−5	64	0	37	−10	53	−4	51	−3
3,000	41	−3	31	−13	72	+7	35	−10	51	−6	42	−8
4,000	35	−8	13	−31	52	−10	------	------	51	−5	64	+14

VAPOR PRESSURE (*mb.*)

Surface	8.59	+0.37	10.75	+1.13	4.81	+0.87	13.18	+1.61	7.82	+1.48	10.31	+2.60
500	7.66	+0.37	8.96	+0.42	4.70	+0.87	11.15	+0.75	6.97	+1.46	8.74	+1.79
1,000	5.74	−0.91	7.48	−0.34	3.80	+0.34	8.43	−0.91	5.70	+0.74	6.85	+0.63
1,500	4.59	−1.41	5.95	−1.09	3.20	−0.03	5.19	−3.11	4.36	−0.13	5.56	−0.08
2,000	3.88	−1.05	4.62	−1.14	2.58	−0.25	3.60	−3.01	3.60	−0.34	4.46	−0.16
2,500	3.32	−0.85	3.79	−0.89	2.22	−0.24	2.92	−2.69	2.69	−0.75	3.36	−0.38
3,000	2.73	−0.87	2.32	−1.30	1.96	−0.16	2.06	−2.85	2.38	−0.73	2.09	−0.95
4,000	1.83	−1.29	0.80	−2.38	0.74	−1.11	------	------	2.28	−0.54	1.83	−0.87

[1] Naval air station.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during March, 1929*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,868 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (65 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (40 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°	
Surface	S 13 W	1.1	S 25 W	2.2	N 66 W	5.4	S 48 W	0.2	N 61 W	1.7	S 20 E	0.6	S 77 W	1.8	S 11 W	1.0	S 65 E	2.3	N 51 E	1.1
500	S 23 W	4.4	S 66 W	4.7	------	----	S 56 W	2.0	N 75 W	2.1	S 36 W	4.9	------	----	S 17 W	3.8	S 50 E	5.5	S 77 E	0.6
1,000	S 35 W	5.9	N 80 W	7.1	------	----	N 88 W	3.7	N 79 W	6.4	S 74 W	5.5	S 77 W	5.4	S 34 W	4.3	S 39 E	4.5	N 25 W	1.0
1,500	S 19 W	4.4	N 69 W	10.6	------	----	N 82 W	7.9	N 77 W	7.4	N 85 W	6.9	S 88 W	7.9	S 58 W	4.6	S 36 E	3.4	N 61 W	3.1
2,000	S 81 W	6.1	N 81 W	11.6	N 64 W	10.1	N 85 W	10.6	N 77 W	9.0	N 84 W	7.5	N 78 W	8.7	S 78 W	7.8	S 36 E	2.7	N 41 W	4.6
2,500	N 89 W	8.1	------	----	N 67 W	15.0	N 84 W	12.8	N 74 W	9.4	S 84 W	8.0	N 68 W	9.0	S 83 W	9.3	S 56 E	1.1	N 36 W	5.0
3,000	W	8.6	------	----	N 63 W	14.4	N 86 W	14.5	N 65 W	9.5	S 71 W	8.9	N 74 W	10.7	N 86 W	11.0	N 38 W	0.2	N 29 W	6.2
4,000	N 88 W	10.6	------	----	N 69 W	7.1	N 83 W	15.5	N 68 W	11.8	------	----	N 80 W	10.5	S 87 W	12.5	N 46 W	3.7	------	----
5,000	S 73 W	12.1	------	----	N 46 W	6.2	N 81 W	19.8	N 53 W	16.6	------	----	------	----	S 89 W	16.3	N 73 W	4.4	------	----

Altitude m. s. l.	Medford, Oreg. (446 meters)		Memphis, Tenn. (145 meters)		New Orleans, La. (25 meters)		Omaha, Nebr. (313 meters)		Royal Center, Ind. (225 meters)		Salt Lake City, Utah (1,280 meters)		San Francisco, Calif. (60 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (67 meters)		Washington, D. C. (34 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°		°		°		°		°	
Surface	S 18 E	0.4	S 14 W	1.3	N 87 E	0.5	N 9 W	0.3	S 65 W	1.3	S 62 W	1.4	S 25 W	0.2	N 25 E	0.6	S 24 E	3.5	S 83 W	1.0
500	S 21 E	0.4	S 45 W	4.5	S 11 E	2.1	S 79 W	1.9	S 50 W	5.0	------	----	N 47 W	3.5	N 65 W	2.0	S 33 W	4.5	S 83 W	8.8
1,000	S 13 W	0.8	S 66 W	5.3	S 73 W	3.9	S 87 W	6.8	S 78 W	6.9	------	----	N 23 W	4.8	N 44 W	5.5	S 65 W	2.9	N 83 W	9.5
1,500	S 53 W	1.5	S 80 W	6.5	N 78 W	6.8	N 82 W	7.6	S 88 W	8.3	S 31 E	1.8	N 24 W	4.6	N 40 W	7.8	S 63 W	2.2	N 69 W	10.2
2,000	S 63 W	3.5	S 79 W	6.7	N 78 W	7.4	N 80 W	9.0	S 82 W	8.9	S 76 W	1.7	N 27 W	5.3	N 60 W	9.4	------	----	N 79 W	10.7
2,500	S 83 W	4.8	S 75 W	7.8	N 84 W	9.3	N 76 W	9.8	S 87 W	9.2	N 75 W	2.8	N 21 W	4.7	N 39 W	8.3	------	----	N 86 W	14.8
3,000	N 67 W	7.2	S 72 W	9.1	S 86 W	9.2	N 75 W	11.5	N 77 W	12.5	N 70 W	3.2	N 22 W	5.1	------	----	------	----	S 85 W	16.8
4,000	------	----	S 78 W	10.5	N 86 W	11.9	------	----	N 84 W	16.8	N 85 W	8.4	N 21 W	6.2	------	----	------	----	N 82 W	16.4
5,000	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----	------	----

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

March, 1929, was notable for the unusual warmth during the latter half over the districts from the Rocky Mountains eastward and for the heavy rains over most southeastern districts and the resulting floods with some loss of life and immense damage to property, also for severe floods resulting from the rapid melting of the heavy accumulation of snow during January and February in portions of the upper Mississippi Valley and near-by areas, the details of which appear in another section of this issue.

PRESSURE AND WINDS

Generally disturbed atmospheric conditions existed near the beginning of the month, sharp changes being noted in the temperature over the Rocky Mountain region and stormy conditions existing over the Atlantic coast districts.

By the morning of the 3d low pressure existed in the Southwest and heavy rains had set in over the Gulf States. By the following morning the low pressure had developed into a storm of considerable intensity central over the southern Appalachians and heavy rains continued over the East Gulf States area and had extended northeastward over the Atlantic coast to New York, gradually passing off the Canadian maritime Provinces during the following day, the heavy rains continuing into the New England area.

From the 5th to 7th a low-pressure area moved along the entire northern boundary from the Rocky Mountains eastward to the Atlantic coast attended by light local snows over much of this area, and was immediately followed by another reaching New England by the morning of the 9th, but without much precipitation.

During the first decade there had been little or no precipitation over the far West, except for occasional showers along the immediate Pacific Coast, until near the close of the decade when rain became rather general over the Pacific Coast States, some heavy precipitation occurring in portions of southern California where it was much needed.

By the morning of the 12th a cyclone of wide extent had developed over eastern Colorado, and snow was falling over a considerable region to the northwestward, and the rain area had extended eastward locally to near the Lake region and into the West Gulf States. By the following morning the central low-pressure area had moved slowly northeastward to South Dakota, with continued snow over the northern Mountain region, while the rainfall area had extended eastward to the lower Ohio Valley, the southern Appalachians, and the South Atlantic coast, the rains becoming heavy in portions of the Gulf States. During the 14th the rain area extended eastward to southern New England and continued in the Gulf States, becoming markedly heavy over much of Alabama and near-by portions of Mississippi, Tennessee, and Georgia. As this storm gradually dissipated over the more eastern districts another developed over Missouri, and heavy rains again occurred over portions of the middle Gulf States, nearly 9 inches being reported from Montgomery, Ala., during the 24-hour period ending 8 a. m., March 15. The barometric depression associated with this heavy precipitation moved rapidly from Missouri northeastward to New England by the morning of the 16th, with clearing weather following over most districts, and generally fair weather prevailed over much of the country until the end of the second decade.

At the morning observation of the 21st, low pressure was general over the Great Plains, and by the morning of the 22d precipitation had occurred over an extensive area from the far Northwest eastward to the nothern Rocky Mountains and scattered rains had overspread many districts in the East from southern Texas northeastward to the Ohio Valley and into portions of the lower Lake region, some heavy falls being again reported from Alabama and portions of near-by States. During the 24 hours ending 8 a. m. the 23d, the pressure remained low from the Mississippi Valley eastward and heavy rains continued in Alabama and near-by areas, and extended northward into Tennessee, where, in portions of the Cumberland Mountain area, excessive rains amounting to from 6 to 10 inches occurred, one station reporting a total fall of 10.31 inches in 12½ hours.

From the 24th to 30th there was mainly only scattered precipitation over central and eastern districts, and only local showers prevailed in the far West until near the end, when some good rains occurred in the more northern districts.

At the end of the month pressure was low and the weather threatening over portions of the Great Plains, and by the morning of the 31st rain or snow had set in over a considerable area from northeastern Colorado and southeastern Montana eastward to the upper Lakes, the snow or rain changing to glaze in portions of this area. Heavy snows were reported locally over a narrow strip from southeastern South Dakota to southern Wisconsin and the Lake Michigan area.

The anticyclones were mainly unimportant, though that entering the Missouri Valley from Canada about the 8th brought sharp changes to cooler over most northern districts as it passed eastward to the Atlantic coast by the morning of the 12th. Another anticyclone formed over the Plateau region about the 14th and brought moderate changes to cooler as it gradually moved eastward and southeastward to the south Atlantic coast by the morning of the 19th. No important anticyclone occurred during the last decade.

The average pressure at sea level for the month was below normal in all portions of the United States and Canada as far as observations disclose, save in the far western coast districts of both countries. Over the central-northern areas the negative departures from the normal were usually large and some localities reported about the lowest individual sea level pressures of record for March.

The pressure changes from the preceding month of February were unusually large and covered all parts of both countries. The distribution of the average pressure and changes from the normal and from February, 1929, are shown graphically on the usual charts.

Windstorms during the month showed, as was to be expected, a sharp increase over those for the preceding months of January and February, particularly those of tornadic character, of which more than 20 were reported, these occurring mainly during the last decade. Only a comparatively small number of these were attended by loss of life or great property losses.

Full details of all damaging wind and other storms are found in the table at the end of this section.

TEMPERATURE

As shown by Chart No. I, of this issue, March was warmer than normal in all portions of the United States, and Canada likewise, as far as shown by available observations, save for a few localities along the Pacific coast and in portions of the far Southwest, where the month was slightly cooler than usual. Over most of the districts from the Rocky Mountains eastward to the Atlantic coast the positive departures ranged from 4° to 10° and in some cases the monthly means were among the highest of record for March.

Considering the temperature by weeks, that ending March 5 was moderately higher than normal in all parts from the Mississippi River eastward, save in most of the Gulf States; the period was also warmer than normal over the Northern States from the Mississippi River westward and along the Pacific coast, the period being particularly warm from Montana and the Dakotas eastward. It was cooler than normal in the middle and southern Plains and Rocky Mountain regions and the Southern Plateau.

The week ending March 12 was distinctly warm over the central and northern Plains and most of the Rocky Mountain States. In most eastern districts this period was cooler than normal.

The third week was abnormally warm over much of the country, particularly in the Missouri Valley and to the eastward where the averages ranged up to as much as 15° per day warmer than normal. From the lower Mississippi Valley northwestward to southern Oregon and thence southward the week was cooler than normal.

The week ending March 26 was again abnormally warm over the greater part of the country where unusual warmth had prevailed during the preceding week. From the Rocky Mountains westward the week was mostly moderately cooler than normal. This week had some unusually high temperatures for the season of the year, many stations reporting the highest March temperatures of record from the 23d to 25th.

The period from the 26th to the end of the month continued mostly warmer than normal over the districts from the Missouri Valley eastward and southeastward to the Atlantic Coast, the period being particularly warm over the Southeastern States. In the western districts and over the middle and southern Plains the week was mainly cooler than normal, save in portions of California and near-by areas of the far Southwest where there were small positive departures.

The important warm periods of the month were mainly during the last decade, particularly about the 22d to 26th, when temperatures were well above 90° over large areas in the Middle and South Atlantic and Gulf States, the Ohio Valley, and portions of the middle and southern Plains. High temperatures also prevailed on the 28th and 29th over most Mountain and Plateau States and over the Northern States from Montana and Idaho eastward to the upper Lakes. At a few points on the Pacific Coast the highest temperatures were reported during the first few days, San Francisco, Calif., reporting a maximum temperature of 81° on the 3d, the highest ever reported so early in the month.

Minimum temperatures were mainly not unusually low, though readings of 20° below zero or even lower were reported from a few exposed localities in the higher elevations of the central Rocky Mountain States and along the northern border from Minnesota to New England, the lowest reported for the entire country, 33° below zero, occurring in northern New England.

PRECIPITATION

The distribution of precipitation was somewhat unusual, the amounts being in some cases far heavier than normal for March, while in others the total falls were decidedly less. Generally the monthly amounts were above normal from the southern Plains eastward to the Atlantic coast, with important areas in the Southeastern States having two or even three times the usual monthly amounts, notably in southern Alabama and nearby areas in Georgia, Florida and Mississippi, with local falls of 20 inches or above, the maximum fall, 33 inches, being reported from Elba, a point in southern Alabama. Other areas, principally in Tennessee, Kentucky, Louisiana, and North Carolina, reported amounts above 10 inches.

Precipitation was likewise above normal, but to a less extent, over an extensive area from the northern Rocky Mountains eastward to and including portions of the Great Lakes and over near-by portions of the Mississippi Valley.

Damaging sleet and glaze storms occurred in portions of Michigan on the 6th causing serious damage to overhead wires, trees, etc.

RELATIVE HUMIDITY

The percentages of relative humidity were mainly less than normal. The deficiencies were not confined to any particular section, as cases of excess occurred indiscriminately over small areas, but mostly along the northern border and in portions of other districts.

Some large deficiencies occurred in southern Washington, northern California and portions of the Great Plains.

SNOWFALL

There was a rather wide distribution of snowfall, but the monthly amounts were very generally less than usually falls in March, save in the Rocky Mountain regions, where the falls were usually at least equal to or greater than normal. Over the mountains of the Pacific Coast States the snowfall was mainly decidedly less than the usual March amounts.

Some heavy falls, unusual so late in the season, were reported locally as follows: Williston, N. Dak., 7.8 inches on the 7–8; Eastport, Me., 16.4 inches on the 28–29; Yankton, S. Dak., 6.0 inches on the 31st; and Green Bay, Wis., 16.5 on March 31–April 1.

West of the Rocky Mountains the precipitation was practically everywhere less than normal, and over important areas in this part of the country a deficiency has existed for several months, particularly in California and parts of other Pacific Coast States.

SEVERE LOCAL STORMS, MARCH, 1929

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Tyler, Tex., and vicinity	3	5 p. m.	2,000		$100,000	Heavy hail	Considerable damage, chiefly to property in the city.	Official, U. S. Weather Bureau.
Luling, Tex. (near)	4	2 a. m.	350		10,000	Tornado	Damage chiefly to oil derricks and oil-field equipment.	Do.
Fort Wayne, Ind	6	5 p. m.			1,500	Wind	Power and telephone lines damaged; several roofs blown off.	Do.
Bismarck, N. Dak	6					Glaze	Overhead wires down; many poles broken	Do.
Michigan, Wisconsin, northern and western New York, and northern Ohio.	6-7			1		Wind	Many buildings torn down; traffic inpeded; numerous plate glass windows broken; many personal injuries.	Do.
Lancaster, Pa., and vicinity.	7	P. m.		1		do	Two schoolhouses and 10 dwellings damaged; trees uprooted; electric wires blown down.	Do.
Maryland and Virginia	7				900,000	Gales	Roofs, chimneys, fences, and windows damaged; overhead wires broken; trees uprooted; small buildings wrecked.	Do.
Parkersburg, W. Va	7					Wind	Overhead wires and signs blown down	Do.
Six Mile, Pickens County, S. C.	13	8:30 p. m.	100	9	30,000	Tornado	Five houses and a cotton gin demolished; 10 persons injured; path 230 yards long.	Official, U. S. Weather Bureau. Greenville News (S. C.).
Bronson, Tex., and vicinity.	18	11 a. m.	5,000		15,000	Hail	Small crop injury; other property damage	Official, U. S. Weather Bureau.
Cotulla, Tex	21	3 a. m.	1,800			Heavy hail	Livestock killed; many acres of onions destroyed	Official, U. S. Weather Bureau.
Tomball to Hufsmith, Tex	21	10:30 a. m.	10,560		2,300	do	Crops and other property damaged	Do.
Zavalla and Beaumont, Tex.	21	do	10,560		10,000	do	Damage chiefly to buildings	Do.
Yakima Valley, Wash	21					Wind	Wall of packing house blown over, haystacks and signs torn down.	Do.
Sanford, Miss. (near)	21					Heavy hail	Character of damage not reported	Do.
Spindletop, Tex	22	1:30 a. m.				Wind	Many oil derricks demolished; other oil-field equipment total loss.	Do.
Fowler to Del Rey, Calif	22	3:30 - 3:45 p. m.				Tornado	No damage resulted	Fresno Bee (California).
Alexandria to Pineville, La.	22	4:20 p. m.	3,520		100,000	Severe thunder squall.	Numerous buildings, plate-glass windows, oil-storage tanks, and wires suffered considerable damage; several persons injured; path 3 miles.	Official, U. S. Weather Bureau.
Bethel, N. C	22					Tornadic wind	Character of damage not reported	Do.
Conetoe, N. C	22				20,000	do	Many stables and outbuildings demolished; giant trees uprooted; chimneys blown off.	Official, U. S. Weather Bureau. Daily Southerner (Tarboro, N. C.).
York County, S. C., to Chatham County, N. C.	22	P. m.		1	75,000	Tornado	Many buildings badly damaged, 1 wrecked; trees uprooted; 20 persons injured.	Official, U. S. Weather Bureau. Charlotte Observer (North Carolina).
Fayette to Harriston, Miss.	22-23			3		Probably tornado	Character of damage not reported; 1 person injured.	Official, U. S. Weather Bureau.
Tuscaloosa, Lamar, Lauderdale, Blount, Talladega, and Calhoun Counties, Ala.	22-23			5	40,000	Severe wind and a tornado.	Many persons injured; a school building wrecked; other minor damage; tornado at Merrellton.	Do.
Macon, Ga	23	8-9 a. m.	3,520			Small tornado	Numerous small buildings demolished; shade trees twisted; telephone service impaired.	Do.
Chester, S. C	23	11:30 a. m.	100		4,000	do	Minor property damage over path 15 miles long	Do.
Catawba, S. C	23	A. m.			2,000	Wind squall	Minor property damage	Do.
Plains, Ga	23	do		2	2,000	Small tornado	Several small houses demolished	Do.
Browns Crossing, Baldwin County, Ga.	23	9 p. m.			2,000	Probably tornado	Several small residences damaged	Do.
Blakely, Ga. (near)	23				5,000	Tornado	5 houses, a church and 2 barns damaged; trees uprooted.	Do.
Oostanaula to Calhoun, Ga.	23				6,000	Small tornado	Several buildings and barns demolished; 5 persons injured.	Do.
Chatsworth to Nicholsville, La.	23					do	A few houses and barns wrecked	Do.
Greenwood, S. C	23				2,000	Wind	Minor property damage	Do.
Newton (near), Fayetteville and Tarboro, N. C.	23					Tornadic winds	Tobacco barns, stables, and packing house blown down, and 1 person injured near Tarboro; character of damage at other places not reported.	Do. Tarboro Daily Southerner (N. C.)
Cedar County, Iowa	24	10 p. m.			2,800	Tornado	Buildings on 5 farms demolished	Official, U. S. Weather Bureau.
Hanover to Apple River, Ill.	24	11 p. m.	3,520		2,000	Wind	Considerable property damage over path 20 miles long.	Do.
Linn County, Iowa	24				2,000	High winds	Some buildings damaged	Do.
Terre Haute, Ind	25					Tornadic wind	4-room house demolished	Do.
Columbus, Ga	28	1 a. m.			15,000	Small tornado	7 houses demolished; numerous residences more or less damaged; electric service impaired.	Do.
Tupelo, Miss	29					Heavy hail	Character of damage not reported	Do.
North-central and Central States.	30-Apr 1.					Wind, rain, sleet, and snow.	Much damage to overhead wire systems; traffic delayed; trees and buildings damaged.	Do.
Keokuk, Iowa	31	3:15 p. m.			2,000	Hail	Greenhouses damaged	Do.
Poyner to Doniphan, Mo.	31	8:30 p. m.	50-440		175,000	Tornado	Many large buildings almost totally wrecked; livestock injured; farm property damaged; 4 persons injured.	Do.
Memphis, Tenn., and vicinity.	31	P. m.			30,000	Wind	A hangar and 7 planes wrecked; telephone and lighting service impaired.	Do.
Mineral Point, Mo	31		100-300		5,000	Probably tornado	2 small buildings completely wrecked; others damaged.	Do.
Winslow, Ark	31					Heavy hail	Considerable property damage	Do.

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FIGURE 1.—An airplane view of the town of Elba, Ala., March 15, 1929. (Photo by Fourth Photo Section, Air Corps, Maxwell Field, Montgomery, Ala.)

RIVERS AND FLOODS

By H. C. FRANKENFIELD

With high pressure predominating over the middle Atlantic Ocean and low pressure to the westward as far as the Rocky Mountains during the last days of February and the first three weeks of March, there was naturally an abundance of rain. At times the low pressure area extended from Canada to Mexico and the Gulf, and from the Ohio Valley southward the resulting rains were torrential.

Between February 26 and March 23 there were four distinct periods of heavy rain as follows: February 26–28, March 4–5, March 12–15, and March 21–23. The rains that fell during the first three periods were very heavy over Georgia, Alabama, northwest Florida, and southern Mississippi, those of the third period exceptionally so, while the rains of the fourth period were heaviest over the drainage basins of the Cumberland, Tennessee, and upper Kentucky Rivers. During the third period the average rainfall over the upper basin of the Altamaha River of Georgia approximated 4.7 inches, over the basin of the Flint River of Georgia 6.3 inches, over the basin of the Chattahoochee River of Georgia and Alabama 9.6 inches, over the basins of the Choctawhatchee and Conecuh Rivers of Alabama and northwest Florida 14.8 inches, over the basin of the Mobile River of Alabama 7 inches, and over the Pascagoula and Pearl River Basins of Mississippi 6 inches. At Elba, Ala., in the drainage of the Choctawhatchee River the rainfall from March 12 to 15 amounted to 29.60 inches, partly estimated, however, as the rain-gage was carried away by the flood waters on March 14 after a measurement of 14 inches for the period from 8 a. m. to 4 p. m. The total estimated amount for the 24 hours ending at 8 a. m. March 15 was 20 inches. At River Falls, Ala., in the drainage of the Conecuh River, the rainfall for the same period was 20.23 inches, of which 11.20 inches occurred during the 24 hours ending at 8 a. m. March 15. This amount was also partly estimated, as the gage was carried away at 5 p. m., March 14. At Brewton, Ala., in the same basin, the rainfall during this period was 16.26 inches. These were the heaviest rains reported, with the basin of the Chattahoochee River not far behind.

The following table gives the approximate rainfall for the four periods previously mentioned. There were some lesser falls between the periods, but none of sufficient conequence to materially affect the flood conditions:

TABLE 1.—*Period rainfall, February 26 to March 23, 1929*

Drainage basin	Feb. 26–28	Mar. 4–5	Mar. 13–15	Mar. 21–23	Total
James	2.16	1.85	1.07	0.33	5.41
North Carolina	2.15	2.07	1.22	1.15	6.59
Peedee	1.23	1.38	1.88	1.23	5.72
Santee	2.97	2.52	1.68	1.90	9.07
Savannah	4.57	4.42	2.78	2.66	14.43
Altamaha, Ocmulgee, and Oconee	4.16	3.98	4.70	1.70	14.54
Flint	4.46	3.30	6.34	0.81	14.91
Chattahoochee	5.47	4.37	9.64	1.40	20.88
Apalachicola (proper)	0.71	0.67	3.10	-------	4.48
Choctawhatchee	4.10	3.00	14.81	1.16	21.91
Conecuh	5.30	3.15	15.00	0.70	23.45
Alabama	4.39	3.40	6.60	3.21	17.60
Tombigbee	2.91	1.47	7.32	4.46	16.16
Pearl and Pascagoula	2.70	1.84	6.04	2.33	12.91
Cumberland	1.49	1.45	1.38	4.76	9.08
Tennessee	2.28	1.42	2.55	3.89	10.14
Lake Erie	-------	0.08	1.82	0.32	2.22
Lake Huron	-------	-------	0.61	0.06	0.67
Lake Michigan	-------	-------	1.19	0.18	1.37
Yazoo	1.69	1.11	2.22	4.14	9.16

The briefest glance at the above table will disclose the regions of maximum floods—Georgia, Alabama, and northwest Florida. The heavy rains of February 26–28 soon brought all their rivers to flood, and the climax followed the enormous rainfalls of the third period, March 13–15. The rains of the fourth period, six days after, were the lightest of the four periods and were instrumental mainly in prolonging the prevailing high stages without creating new crests.

Choctawhatchee and Conecuh Rivers.—By far the greatest and most destructive of the floods were those in the Choctawhatchee and Conecuh-Escambia Systems of Alabama and Florida. They attained heights far beyond any previous records, and it is to be regretted that their description must be brief. However, lack of space permits no alternative. As a matter of fact any description would fail to do justice to the actual facts, as the floods so far exceeded the previous great floods of 1861 and 1916 that intelligent comparison would be impossible, as the differences in crest stages would not afford a true measure of the differences in conditions.

Three periods of heavy rains during the month of February caused either bankful stages or more, and the saturated soil afforded an excellent foundation for the disasters to come.

The town of Elba, Ala., on the Pea River, an important tributary of the Choctawhatchee, was inundated to a considerable depth, 10 feet or more in places, as were the towns of Geneva, Ala., and Caryville, Fla., on the main stream, while the town of Westville opposite Caryville was partially overflowed. The breaking of a hydroelectric power dam on the Pea River on March 14 increased the stage at Elba, and probably to some extent the Choctawhatchee below Geneva.

The floods in the Conecuh-Escambia River were equally disastrous, and the waters covered the towns of River Falls, Brewton, Pollard, and Flomaton, Ala., and considerable portions of the towns of Century, Bluff Springs, McDavid, Pine Barren, and Molino, Fla.

Every industry and every activity, both urban and rural, suffered heavily. Traffic on railroads and highways was suspended and river navigation interrupted on the Chochtawhatchee River below Geneva, Ala.

Owing to the unprecedentedly high stages reached by the flood waters, the loss and damage account was very large. The total reported was $4,746,500, divided as follows: Tangible property, $3,713,500; livestock and other movable property, $100,000; suspension of business, $1,000,000. The reported value of property saved through the flood warnings was only $31,000, as the rivers were so high that protective measures were useless. No human lives were lost.

Flood warning service on the Choctawhatchee and Conecuh Rivers was inaugurated only about five months ago, and with little or no previous data to serve as a basis, the work of forecasting the flood stages was attended by much difficulty, which was enhanced by numerous delays in telegraph service that were to be expected under the circumstances. Nevertheless the warnings, which were both frequent and timely, were very satisfactory as a whole, and were instrumental in saving many human lives and much property. In the dissemination of warnings the Weather Bureau was greatly assisted by the press, the Louisville & Nashville Railroad, and radio broadcasting station WCOA. In addition, through the courtesy of the commandant of the Pensacola Naval Air Station, an airplane dropped warnings over Caryville, Fla., on the afternoon of March 15, nearly two days before the arrival at that place of the crest of the flood.

Apalachicola system.—The rainfall distribution over the drainage area of the Apalachicola River was not so

uniform as over the rivers of southern Alabama. While the total fall over the Chattahoochee area was only 1 inch less than over Alabama, its distribution was more uniform, although its effects were much the same. Over the Flint River area, however, the average rainfall was nearly 6 inches less than over the Chattachoochee area, and over the Apalachicola area proper, about 17 inches less. Accordingly the Flint River flood crests, except at Montezuma, Ga., were about 2 feet lower than during the great flood of January, 1925. The upper Chattahoochee crests approximated those of January, 1925, while the lower Chattachoochee reached the highest stages of record, pouring down an enormous volume of water which, when united with that from the Flint River, raised the Apalachicola River from 1 to 2 feet above previous high stages of January, 1925, notwithstanding the fact that the direct precipitation over its basin was relatively small.

Each of the four periods of heavy rain before mentioned was followed by flood conditions and with the maximum effect from the third period. The first warnings were issued on February 26 during the first rain period, and thereafter as regularly and frequently as required. Despite the complexity of conditions caused by the succession of heavy rains, the warnings, always timely, were very accurate, and in the Apalachicola Basin proper, where much more territory was inundated than in January, 1925, it is doubtful whether the damage and loss were as great, owing to the emphatic character of the warnings and the precautions taken in consequence. As early as 9 a. m., March 15, five and six days in advance of the crests, warnings were issued for the most dangerous flood in the history of the Apalachicola River.

During the floods five lives were lost, three in Flint and two in Chattahoochee territory. There was also one drowning in the Willacoochee River near Fitzgerald, Ga. At West Point, Ga., on the Chattahoochee River, the Atlanta & West Point Railroad tracks were under water from 3 to 6 feet deep, and traffic was suspended for 48 hours. The entire downtown section, nearly all residential districts, and many square miles of surrounding farm lands were inundated, and traffic was conducted in skiffs and motor boats. The city of Eufaula, Ala., is safe from flood, but on the Georgia side of the river a few residences and some filling stations were overflowed. The city of Fort Gaines, Ga., south of Eufaula, underwent its first flood experience.

At Montezuma, Ga., on Flint River, many residences and stores were under water, and boats were used in the streets. The town of Newton, Ga., on Flint River, was covered, as it is always when the stage at Albany, Ga., exceeds 30 feet, but the inhabitants were notified by long-distance telephone to vacate the town on March 2 and again on March 17. Other towns below were also more or less flooded.

There were the usual delays due to washouts, bridge failures, and highway damage, as well as much inconvenience and interruption of business, but as a whole the loss and damage were surprisingly small, when the wide extent and great volume of flood waters are taken into account. Railroads and State roads suffered to the extent of about $600,000, about equally divided; buildings, factories, etc., about $100,000; cost of moving property, $30,000; prospective crops, $22,000; livestock and other movable property, $18,000; and losses due to suspension of business, $79,000; making a total of $849,000. The reported value of property saved through warnings was in excess of $300,000.

Altamaha system.—The average rainfall over the drainage areas of the Oconee and Ocmulgee Rivers of Georgia for the four great rain periods was between 14 and 15 inches, about the same as over the Flint drainage to the westward. However, over the Altamaha Basin proper the rainfall was very much less, probably not over 6 inches, and very fortunately so, as any rainfall approximating that to the westward and northwestward would have caused throughout the Altamaha a flood exceeding that of January, 1925. As it happened, no records were exceeded throughout the entire basin, although at Dublin on the Oconee and at Hawkinsville and Abbeville on the Ocmulgee River, the differences were not large.

The useful warnings were issued regularly, and were the means of saving $75,000 in livestock and $145,000 in movable property.

Loss and damage totals aggregated about $400,000, of which $200,000 was to bridges and highways and $40,000 to crops.

Alabama system.—The floods in the Alabama River system were the sequences of the same rainstorms that were responsible for other southern floods, and were very similar in character and destructiveness, although the flood heights were relatively not so great as in the Conecuh, Choctawhatchee, Chattahoochee, and Flint systems. The average rainfall over the Alabama Basin for the four principal rain periods was 17.6 inches, against 21 to more than 23 inches to the eastward. The greatest differences occurred during the third period from March 13 to 15, when the Alabama system rains were about 8 inches less than to the eastward.

It is unnecessary to recount the flood effects. They were about of the same magnitude as elsewhere in the South, and losses were proportionately great. Those reported were as follows: Tangible property $1,583,933; matured crops, $14,950; prospective crops (6,630 acres), $32,585; livestock and other movable property, $14,060; suspension of business, $41,568; total, $1,687,156.

Warnings were timely, frequent, and accurate. The problem of flood forecasting in this district is much complicated in that the operation of the gates at the power plants along the rivers frequently render it impossible to forecast definite river stages for more than 12 to 24 hours in advance. Nevertheless the warnings issued were of great utility, and the reported value of property saved thereby during these floods was $1,230,472. The total reported saving in the State of Alabama, not recorded elsewhere, was somewhat in excess of $2,000,000.

Numerous expressions of appreciation of services rendered by the Weather Bureau were received, and a single one will indicate the general character:

AMERICAN RED CROSS, FAMILY SERVICE,
Montgomery, Ala., April 3, 1929.

Mr. P. H. SMYTH,
Meteorologist, U. S. Weather Bureau,
Montgomery, Ala.

MY DEAR MR. SMYTH: The Montgomery County Chapter of the American Red Cross wishes to extend to you their thanks for your cooperation in the tremendous problems that faced us during our recent disaster. We fully appreciate the fact that without the service which you were able to render our efforts to relieve suffering would have been futile.

Very truly yours,

BOARD OF DIRECTORS,
MONTGOMERY COUNTY CHAPTER A. R. C.
By (Sig.) MABLE CULTER, *Executive Secretary.*

Tombigbee system.—The Tombigbee River at Demopolis, Ala., passed its flood stage of 39 feet on February 28, and did not fall below that point again on the decline until April 9, a period of 40 days. The Black Warrior River at Tuscaloosa, Ala., passed its flood stage of 46 feet on February 28 also, but it lapsed twice before rising to its highest crest of 62 feet on March 15, and again before

attaining the second great crest of 61.3 feet on March 24. It fell below the flood stage by the early morning of March 28, but continued above the flood mark along the lower reaches of the river until April 9.

The overflowed area extended along the Tombigbee River for a distance of 250 miles above its mouth, and the width of the inundated area varied from one-half to as much as 8 miles. The extreme upper Tombigbee was not in flood, but for a distance of about 100 miles below Columbus, Miss., there was moderate overflow. The Black Warrior overflowed for a distance of about 150 miles above its mouth as did also the Noxubee and other tributaries of the Tombigbee. In all about 450 square miles of land were overflowed. The usual warnings were issued promptly and were well verified. Reports of losses were very incomplete, but partial returns showed a total of $583,700, of which $293,100 were in tangible property, $19,000 was in crops (4,000 acres); livestock, $43,400; and suspension of business, $228,200. Reported value of property saved through the warnings, $760,000. One item for which no figures can be given was the loss of an immense quantity of oysters on the reefs in Mobile Bay from the great volume of fresh water from the Alabama and Tombigbee Rivers. On the other hand the floods were of distinct value to lumbermen who were able to float much lumber near the mouth of the Tombigbee River.

Pascagoula and Pearl systems of Mississippi.—The average rainfall for the four great rain periods in the Pascagoula and Pearl systems was about 13 inches and the story of the floods was a repetition in somewhat moderate form of what occurred to the eastward.

Losses were not excessive, considering the area involved, as the season was too early for large crop losses. The reported losses were $200,900, of which $118,400 were in tangible property, $43,400 in crops, $5,100 in livestock and other movable property, and $34,000 from suspension of business. Reported value of property saved through flood warnings, $49,500.

Ohio River system.—The flood in the Ohio River which began at Pittsburgh, Pa., during the closing days of February passed down the river in the usual manner, and until the mouth of the Green River of Kentucky was reached, the crest stages reached were but little above the flood stages. Below the mouth of Green River the crests were from 4 to as many as 9 feet above the flood stages, with a crest at Cairo, Ill., of 51.9 feet, 6.9 feet above the flood stage, on March 20. Another rise began at Cairo on March 28 and the river at Cairo did not again fall below the flood stage until April 22, and the report for that district will appear in the Monthly Weather Review for April, 1929. There were no losses of consequence and the usual warnings were issued at the proper time.

There were also numerous floods in the tributaries of the Ohio River, and those in the Cumberland and Tennessee Rivers may be classed as great floods. The same four general rain periods that caused the floods in the South Atlantic and East Gulf States were responsible for these floods, but as the total rainfall was much less, only the fourth rise reached the proportion of a flood.

Cumberland River.—The floods in the Cumberland River were caused by the third rain of the month, which was the heaviest of the four periods over this drainage basin. Over the Caney Fork area there were 10.31 inches of rain from 6:30 a. m., March 22 to 7 a. m., March 23, of which 5.10 inches fell from midnight to 3 a. m., March 23. This enormous fall was reflected on the gage at Carthage at the mouth of Caney Fork. The crest stage of 69.4 feet at Burnside, Ky., at 4:30 a. m., March 24, was only 0.1 foot below the record stage of January 29, 1918, while at Rock Island, Tenn., on Caney Fork, the crest of 38.8 feet, about 3:30 p. m. of March 23, was by far the highest stage ever measured at that place. The gage was washed away about 6:30 p. m. of the same date.

The flood at Nashville covered the low districts of the city from about Fifth Avenue South almost to Twelfth Avenue North, and also large areas of North and South Edgefield on the opposite side of the river. Business in some sections was paralyzed and eight street-car lines were out of commission for some time, yet the loss and damage were quite small considering the magnitude of the flood.

Six lives were lost along the Kentucky headwaters of the Cumberland River and hundreds of families were driven from their mountain homes.

The total reported loss and damage amounted to $3,098,900, divided as follows: Tangible property, $2-547,000; livestock and other movable property, $108,250; matured crops, $2,400; prospective crops, $107,000, and business suspension, $334,250. The reported value of property saved through the warnings was $1,891,000.

According to Mr. Warren R. King, district engineer, United States Geological Survey, Chattanooga, Tenn., the discharge at Nashville was greater than that during the flood of two years ago, when the crest stage was 56.2 feet on January 1, whereas the crest of the flood of March, 1929, was only 50.9 feet. The flood waters from Caney Fork were the first to reach Nashville, the flood from the Kentucky headwaters following and holding the high stage at Nashville with another slow rise that continued several days.

Tennessee River drainage.—There were no floods in the Tennessee River proper above the mouth of Clinch River, but below they were general, although the flood stage of 21 feet was not quite reached at Decatur, Ala. As a rule crest stages ranged from 2 to 7.6 feet above the flood stages, the maximum at Rockwood, Tenn., the scene of the drowning of eight boy scouts who were trapped in their bungalow. At Chattanooga, Tenn., the crest stage was 38.7 feet, 5.7 feet above the flood stage, at 11:50 p. m., March 25. On the previous day the drift passing Chattanooga was the greatest in quantity and the most varied in character that had ever passed that place, consisting, as it did, of logs, oil drums, freight cars, houses, furniture, telephone poles, and what not.

Except in the Clinch River, tributary floods above Chattanooga were not important, with only a few thousand dollars damage along the Big Pigeon River.

The greatest tributary disaster occurred along the Emery River where 18 lives were lost and damage done to the amount of perhaps $4,000,000, of which $3,000,000 fell upon the city of Harriman, Tenn. At this place the Emery River reached a stage of 61.2 feet at 10:30 a. m., March 23 (District Engineer Warren R. King, U. S. Geological Survey), with a discharge of 153,000 second-feet, or one-third more than the discharge of the Tennessee River at Chattanooga during its greatest crest, that of 57.7 on March 11, 1867.

Other high tributary stages were 28 feet (estimated) in the Elk River at Fayetteville, Tenn., on March 23, exceeding the previous high record of the spring of 1920 by 4.5 feet and 43.8 feet in the Duck River at Columbia, Tenn., 1.8 feet below the record stage of March 30, 1902.

Losses and damage were not large below Florence, Ala.—only about $77,000 reported—but they were very heavy above. The total given for the entire Tennessee River basin was $4,863,665, almost entirely in tangible

property, highways, etc. Losses due to suspension of business amounted to $101,665. Naturally very little planting had been done, and crop losses were only about $6,000. The reported value of property saved through the flood warnings was $1,224,000, mostly in Chattanooga and vicinity.

Other Ohio tributary floods.—All of the northward flowing tributaries of the Ohio River in the State of Kentucky were in flood to a greater or less extent. In the Levisa Fork of the Big Sandy River the crest stages on March 23 and 24 were not much below the highest stages of record, and at Pikeville, Ky., the river rose about 45 feet in about 33 hours, flooding more than one-half the houses in the town. Other towns were also flooded. No figures as to losses were obtainable except at Pikeville, where the total was placed at between $100,000 and $150,000.

The Kentucky River flood was most severe in the North Fork between Beattyville and Jackson and in the districts drained by the South and Middle Forks. There was no flood of consequence in the lower Kentucky River.

Loss and damage as reported amounted to about $250,000, and were heaviest in Lee and Owsley Counties or the South Fork district. Two persons were drowned. The system of radio distribution of forecasts and warnings functioned excellently and certainly saved many lives and much property, as telegraph and telephone lines were disabled during the early hours of rising waters.

The Green River flood was moderate, and no material losses were reported.

The floods in the northern tributaries of the Ohio River were continuations of those of late February, and were given brief mention in the MONTHLY WEATHER REVIEW for that month. (The flood of late February in the Miami River of Ohio, report of which was postponed for this issue of the REVIEW, is discussed at the end of this report.)

Great Lakes drainage.—Warm weather during the last days of February and early March caused moderate floods in the St. Joseph River of Indiana and the Grand River of Michigan, with a second one about the middle of March, due to moderate rains. There was no damage of consequence except from the Grand River in the vicinity of Grand Rapids, Mich. Two parks were overflowed, and a number of cottages damaged by ice and water, a number of cottagers being driven into different quarters. The official in charge of the Weather Bureau office at Grand Rapids remarked as follows regarding this flood:

> On account of the remarkable similarity that existed between conditions, as regards snow cover and precipitation during December and January last, and the corresponding period in 1903 and 1904, when a river stage of 20.4 was reached at Grand Rapids, the situation was watched very carefully. It is believed that the small amount of precipitation in February and the first two weeks of March this year, together with the almost ideal melting of snow cover and absence of ice jams during time river was in flood, prevented the occurrence of a marked flood at this station.

Atlantic drainage except the Altamaha River.—Moderate rains and high temperatures with melting snows caused moderate floods from March 17 to 19 in the Connecticut and Hudson River systems, and a second equally moderate one in the lower Connecticut between March 24 and 28.

Warnings were issued whenever possible, and reported losses were moderate.

There was a flood of marked proportions in the North Branch of the Susquehanna River above the Pennsylvania line, and a moderate one below, between March 14 and 18. On March 11 the average depth of snow remaining on the ground in the upper drainage basin was 4.6 inches with a water content of about 1.25 inches. Moreover a number of low ice gorges had formed in February and were consolidated by low temperatures during the first two weeks of March. Then moderate rains and high temperatures brought about the floods which caused damage that would have been much greater had not dynamite been used to dislodge an ice gorge that threatened one of the bridges of Binghamton, N. Y., as well as the overflow of several thousand homes.

Loss and damage as reported amounted to about $200,000, almost entirely to tangible property, while the estimated value of property saved through the warnings was $50,000. The damage below Binghamton probably did not exceed $10,000.

The rains of February 27 and 28 were followed by an unimportant flood below the mouth of the Rivanna River on March 1 and 2. Warnings were issued and damage was inconsequential.

With heavier rainfalls to the southward, the floods in North and South Carolina were more decided, the crest stages during the first 10 or 12 days of the month ranging from 4 to more than 18 feet above the flood stages, with the maximum excess in the Cape Fear River of North Carolina. As the rains during February and March were the heaviest since 1903, the floods were severe and prolonged; yet the resultant damage was not great. A number of highways were closed, but the principal loss was due to suspension of business and delay in planting crops. Tangible losses in North Carolina were about $10,000, and losses due to business suspension $25,000, a total of $35,000, while the reported value of property saved through the warnings was $40,000.

The floods were also severe in the Santee River and its confluent streams, the month opening with virtually all streams in flood. Losses as reported amounted to $248,350, of which $207,500 were mainly in small highway bridges and approaches and young crops in lowlands. Prospective crop losses were $12,950, livestock and other movable property $4,275, and business suspension, mainly in lumbermen's wages in the low country, $22,125. Reported value of property saved through the warnings, $63,312.

As the area covered by maximum precipitation was neared, the flood intensity of course increased, and the flood in the Savannah River, as measured by the crest of 38.7 feet on March 6 at Augusta, Ga., was about the same as on August 27, 1908, and only 1.7 feet below the greatest crest of 40.4 feet on August 17, 1928.

There was the usual rise for each of the four rain periods, although even with the heavy rains, the third and fourth were not serious. The average for the first period was 4.57 inches and for the second 4.42 inches.

The usual warnings were issued promptly, and the final forecast for a crest at Augusta on March 6 between 38 and 39 feet was well verified by the actual crest of 38.7 feet on that date.

Eight human lives were lost during the floods, and the reported loss and damage, all outside of Augusta, amounted to $175,000, of which $75,000 occurred across the river from Augusta, while the reported value of savings through the warnings was $580,000.

Study of these Savannah River floods discloses some very interesting problems, and Mr. E. D. Emigh, the official in charge of the Weather Bureau office at Augusta, Ga., contributed the following relative thereto:

> By the gradual elimination of other possibilities and arguments, it seems more and more likely that the washing out of the 4-foot flash boards at the Stevens Creek dam during the August, 1928, flood will be the ultimate explanation of the excessive rise and

unprecedented behavior of the river at that time. In the working out of future problems, therefore, it would seem to be wise to ignore the inconsistencies between rainfall and crest stage at that time and make use only of the valuable information based on the actual discharge values at the Augusta Locks dam and the effect of that volume of water at the gage.

A very useful chart has just been received from the Savannah River Electric Co., Mr. J. E. Parker, vice president, Birmingham, Ala., showing discharge curves of the Savannah River at Augusta, worked out by that organization from all available streamflow measurements to date. The following data are undoubtedly the most authenic obtainable at this time:

Year	Gage	C. F. S.	Remarks
1888	38.7	304,000	No levee.
1908	38.8	307,000	Do.
1912	36.8	231,000	Do.
1925	36.5	151,000	Levee and South Carolina approach.
1928	40.4	226,000	Do.
1929	37.2	162,000	Do.
1929	38.8	193,000	Do.
Equivalents with present conditions:			
1888	43.3	304,000	Levee planned by Corey, Dabney, and Wingfield to carry 400,000 c. f. s. 2 feet below top, with levees both sides, at stage 36.4 feet.
1908	43.5	307,000	
100 yr.	43.0	287,000	
1,000 yr.	46.2	378,000	
10,000 yr.	48.4	445,000	
	47.0	400,000	

Mississippi drainage.—At the close of March the Mississippi River was in flood from Muscatine, Iowa, to Baton Rouge, La., except at St. Louis, Mo., and reports thereon will appear after the floods subside.

As a result of high temperatures with consequent melting of a large quantity of snow, and ice movement, there was a moderate flood in the lower Wisconsin River from March 17 to 25, inclusive. Warnings were issued and there was no damage of consequence.

In other rivers of Wisconsin and northern Illinois, including the Fox, Kickapoo, Pecatonica, and Rock Rivers, the floods were much more severe and several cities were more or less inundated. As no river and flood service is maintained on these rivers, no very definite statistics are available as to their extent and amount of damage done, except that the following details were reported by the Weather Bureau observer at Moline Airport, Ill., pertaining to the Rock River rise: That the stage of 14.9 feet (caused by an ice gorge one-half mile below the gage immediately after the breakup of the ice) at Moline Bridge at 11:30 p. m. of March 11 was the highest recorded there since June 27, 1892; that about 30,000 acres were overflowed along the river during the flood; and that while no great damage was done in cities, the inundation of roads resulted in the temporary isolation of several small towns, and a number of summer camps and homes near the river were damaged or destroyed.

All interior rivers of the State of Iowa were in flood at some time during the month and it is regretted that lack of space forbids a detailed report thereof.

But little of the heavy snowfall of January and February had melted, and there was but little thawing until about the middle of the second week of March, after which time mild weather caused a rapid thaw to set in and by the middle of the third week there was little snow left. Conditions for flood causation were ideal, and, as a matter of fact, previous to the general floods ice gorges caused local floods for short intervals at many places in the southern portion of the State. All records for the interior rivers for the month of March were broken, and the Cedar and Nishnabotna Rivers exceeded all previous records. There were some local ice gorge floods in the Des Moines River above the city of Des Moines, but the timely use of dynamite prevented serious damage. Below Des Moines the situation was serious and much damage was done.

The floods in the lower Des Moines and Cedar Rivers will be discussed in the next issue of the REVIEW.

The Illinois River remained in flood throughout the month with no prospect of early decline. The February floods caused some inconvenience but very little damage, but during March there was damage and loss to the amount of $175,000, of which $75,000 was to tangible property and $100,000 to prospective crops (100,000 acres). Reported value of property saved through warnings, $28,000.

The floods in the Grand River of Missouri were of rather decided character. The February floods were marked by presistent ice gorges, resulting in great inconvenience and many damaged roads. At Chillicothe, Mo., a gorge held from February 26 to March 10, inclusive. High water prevailed until shortly after the middle of the month, yet losses were very small, probably $15,000 in tangible property, against an equivalent amount, mainly in livestock, saved through the flood warnings.

The outstanding feature in the Missouri Basin was the great ice gorge and resultant flood at and in the vicinity of Bismarck, N. Dak. The ice gorge formed at Huff, N Dak., 14 miles downstream from Bismarck, about March 18 and lasted until March 29 when it gave way under the influence of sunshine and mild temperatures. The gorge extended for a distance of 30 miles, and while lowlands were covered as far back as Mandan, N. Dak., and portions of Bismarck and Mandan were inundated, it does not appear that much damage was done. The river at Bismarck reached a stage of 18.5 feet, 3.5 feet above the flood stage at 9 a. m., March 27, and the gorge probably broke on the following day.

There were also numerous ice gorges above Mandan, but without serious results. The gorge at Williston, N. Dak., moved out on March 24.

Perhaps the most destructive ice gorge of the season was in the Yellowstone River at Miles City, Mont., and in Tongue River which joins the Yellowstone at Miles City.

During a severely cold winter ice had formed in the rivers to a thickness of as much as 51 inches and more than the normal amount of snow had fallen during January and about the normal amount in February. Warm weather, 60°, and a warm rain came during March 5 and at 11:30 p. m. on that date the ice in Tongue River broke. In the Yellowstone River, however, the ice held firmly, and the Tongue River ice was forced entirely across the Yellowstone ice to a depth of 15 feet. Having no other outlet, the ice jammed in the channel of the Tongue until it extended upstream for a distance of 2½ miles with the ice resting on the mud of the river bed for the first three-quarters of a mile. By the evening of March 7 about one-half of Miles City was inundated with backwater flowing from manholes in the main business district. At 3 a. m., March 8, the Yellowstone ice gave way, but the Tongue River gorge persisted until 2 p. m., March 10. It had been frequently dynamited for several days.

The damage amounted to about $50,000, mainly to homes and furnishings.

The Yellowstone River was also gorged at Glendive, Mont., some distance downstream from Miles City, around March 8, damming the water for a distance of 10 miles upstream, and gorges were reported at other places. Losses were small. Press reports indicated similar conditions with severe losses from a gorge and flood in the Big Horn River in the vicinity of Graybull, Wyo.

The snow melting and ice break-up caused pronounced rises in the James and Big Sioux Rivers of South Dakota and the Floyd River of Iowa, tributaries of the Missouri River. The resulting overflows were not serious, and little damage was done.

Other floods mentioned in the table following this report were unimportant and caused no damage.

Miami River flood in February, 1929.—This destructive rise, details of which were not available for publication in the February REVIEW, resulted from the same general combination of rain, frozen ground, snow, high temperature, and ice that caused the other damaging floods in Ohio during February. The official in charge of the Weather Bureau office at Dayton, Ohio, states that in the Miami conservancy district the run-off amounted to 114 per cent, and caused river rises from 10 to 15 feet within 12 hours to stages unprecedented in the history of the flood-control project in that locality. Further details from this official's report follow:

The flood compares favorably in volume with the one of 1898, which is reputed to be the second greatest within the history of authentic flood records in this section. No unusual damage occurred at Sidney, Piqua, or Troy, and the Stillwater River was not as high as in previous years. Englewood Dam on the Stillwater had a stage of 46.9 feet, being 5 feet below the previous high mark. At Pleasant Hill there was some loss caused by the breaking and washing out of 200 feet of a farm levee.

Each of the conservancy dams functioned just as planned so that within the area of the flood-control scheme, the loss was relatively small, and was confined to water backing into sewers or storm sewers not being large enough to carry off the surplus, causing overflows in streets and cellars. However in the section from Auglaise County on the north to Hamilton County on the south, rural districts suffered considerable damage by flooding low lands, county roads, culverts, and bridges. In the upper sections floating ice was blamed to a considerable extent for blocking storm sewers; this condition also blocked culverts which at any rate were too small to care for the unusual rush of water coming from the surrounding hills. In many cases the roads acted as dams, the water finally flowing over them and making falls on the opposite side; the falls gradually ate backward through the roads and caused washouts.

The river stages were the highest in the down-river cities due to the heaviest rainfall being along the lower Twin Creek Valley.

At Hamilton the river rose 10 feet in the 5 hours from midnight the 25th to 5 a. m. the 26th, and the crest 17.4 feet is the highest of record at that point. In Peck's addition—outside the flood-prevention district—the flood left in its wake 200 flooded homes. It is estimated that 150 persons were taken from their homes by boats. In New Miami, a village north or Hamilton, reports state that 300 were made homeless by houses being submerged to depths ranging from 1 to 6 feet. At Middletown the damage in the city consisted mostly of that caused by flooded cellars and backwater in both the business and residential sections. Roads were destroyed and shut off a large rural district from communication with the larger centers. The village of Amanda on Seven Mile Creek suffered along this line. Factories, particularly paper mills, were closed down, and travel was suspended for several days on the main highways. At Moraine City, south of Dayton, manufacturing operations were suspended for two days because of high water backing into electric-power tunnels and flooding the power house.

At Dayton, a levee on the old abandoned canal broke down, flooding cellars and streets in the east section of the city; and on the northern side of the city approximately 100 feet of railroad roadbed was washed out.

The Little Maimi River and its tributaries are reported to have risen to the highest points ever known by them. Yellow Springs, the seat of Antioch College, suffered a water shortage as the water-works pump was forced out of commission by rising waters of this stream.

Springfield was apparently hit the hardest of any section in the State. Buck Creek which runs thorugh the city and empties into the Mad River at the western edge of the city, broke from its banks, and forced more than 200 persons in the valley to vacate homes, and did very heavy property damage, swamping low lands and flooding streets and roads. Fire and flood it is said claimed the greatest toll in the history of Springfield, by the greatest flood in years, and the property damage is expected to reach at least a million dollars. Transportation facilities were halted entirely, and all power had to be shut off. The water supply for domestic purposes was curtailed when a main line connection from the plant broke, forcing factories to close operations. Pandemonium reigned when the water began causing short circuits which resulted in two fires in two of the large plants and in a number of homes while firemen and policemen were carrying on the rescue work. Boats kept for such a crises in a park were reached with great difficulty because the park was flooded and other boats had to be located in order to reach those in the park, and after the lights went out the rescuers were greatly hindered in their work. The situation was the most precarious on record until the late forenoon when the water began to recede. The highest stage of record, 15.1 feet, was observed at our gage on the Mad River below the city about 2 p. m.

No estimate of the total losses caused by the flood is available. As noted above, at a single station (Springfield) the property damage alone amounted to at least $1,000,000; in addition to which, besides all other direct damage to highways, homes, business establishments etc., in other localities, practically every factory in the district was forced to close for a time, with a resultant heavy loss due to suspension of business.

[All dates in March unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC DRAINAGE	*Feet*			*Feet*	
Connecticut: Hartford, Conn	16	17	19	17.2	18
		24	27	18.9	25
Hudson:					
Troy, N. Y	15	15	17	18.0	17
Albany, N. Y	12	15	17	13.6	16
Castleton, N. Y	10	16	16	10.2	16
Mohawk: Schenectady, N. Y	15	15	16	19.8	15
Sacandaga: Northville, N. Y	17	17	17	18.0	17
Susquehanna:					
Oneonta, N. Y	12	14	18	16.5	15
Bainbridge, N. Y	11	15	18	17.9	16
Binghamton, N. Y	14	15	17	17.7	16
Towanda, Pa	16	16	17	16.8	16
Wilkes-Barre, Pa	20	16	18	23.3	17
Chenango: Sherburne, N. Y	8	14	17	9.9	14
James:					
Columbia, Va	18	1	2	23.5	1
Richmond, Va	10	1	2	11.8	1
Roanoke:					
Randolph, Va	20	1	2	21.4	1
		6	7	20.4	6
Weldon, N. C	30	(1)	9	39.5	1-3
Tar:					
Rocky Mount, N. C	9	1	10	10.6	5
Tarboro, N. C	18	3	13	24.3	7
Greenville, N. C	14	3	14	18.6	9
Fishing Creek: Enfield, N. C	15	8	8	15.0	8
Neuse:					
Neuse, N. C	15	(1)	10	19.3	3
Smithfield, N. C	14	(1)	12	21.5	7
		17	18	14.0	17-18
Cape Fear:					
Fayetteville, N. C	35	(1)	9	53.3	2
Elizabethtown, N. C	22	(1)	12	33.8	4
		25	27	25.2	26
Haw: Moncure, N. C	22	(1)	2	28.5	1
Peedee:					
Cheraw, S. C	27	(1)	3	38.5	1
		5	8	36.8	6
		16	17	29.4	16
		24	25	30.0	25
Mars Bluff, S. C	17	(1)	(2)	25.4	5
Lynches Creek: Effingham, S. C	14	5	12	17.3	10
Waccamaw: Conway, S. C	7	11	19	8.0	15-16
Santee:					
Rimini, S. C	12	(1)	(2)	25.3	9
Ferguson, S. C	12	(1)	(2)	17.5	10
Catawba: Catawba, S. C	12	(1)	1	17.0	1
		5	6	16.5	6
Wateree:		1	2	31.8	1
Camden, S. C	24	5	8	31.2	6
		16	17	25.2	16
		24	25	28.8	24
Malta, S. C	14	3	3	14.0	3
		8	8	14.0	8
Congaree: Columbia, S. C	15	(1)	2	25.9	1
		5	8	24.5	6
		23	25	16.6	23
Broad: Blairs, S. C	15	(1)	2	25.2	1
		5	7	23.7	6
		16	16	15.6	16
		24	24	16.4	24
Saluda:					
Pelzer, S. C	7	(1)	2	10.4	1
		5	7	11.0	5
		15	16	9.0	15
		23	23	7.0	23
Chappells, S. C	14	(1)	9	23.6	6
		16	18	17.6	17
		22	26	16.7	24

[1] Continued from last month. [2] Continued at end of month.

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
ATLANTIC DRAINAGE—continued					
Savannah:	*Feet*			*Feet*	
Calhoun Falls, S. C.	6	5	5	7.2	5
Augusta, Ga.	32	(1)	2	37.2	1
		5	7	38.7	6
Broad: Carlton, Ga.	11	(1)	1	17.0	Feb. 28
		5	6	24.5	5
		15	16	17.0	15
		22	23	14.5	22
Altamaha:					
Charlotte, Ga.	15	(1)	(2)	26.7	6
Doctortown, Ga.	10	7	29	12.3	12–13
Everett City, Ga.	10	(1)	(2)	16.0	15–16
Oconee:		(1)	3	35.7	Feb. 28
Milledgeville, Ga.	22	5	9	32.6	6
		15	18	29.6	16
		23	25	23.4	24
Dublin, Ga.	22	2	11	29.5	8
		18	20	24.1	19
Ocmulgee:		(1)	2	25.8	Feb. 28
Macon, Ga.	18	5	8	24.9	6
		15	18	24.7	16
		23	25	19.9	23
Hawkinsville, Ga.	29	2	11	34.9	8
		18	20	32.7	18
Abbeville, Ga.	11	(1)	(2)	19.6	10
Lumber City, Ga.	15	4	28	23.5	12
WEST GULF DRAINAGE					
Apalachicola:					
River Junction, Fla.	20	1	30	35.0	20
Blountstown, Fla.	20	(1)	(2)	28.6	21
Flint:		1	3	26.3	1
Montezuma, Ga.	20	6	9	26.1	7
		16	19	27.4	17
Albany, Ga.	20	1	26	34.4	20
Bainbridge, Ga.	25	3	29	38.1	22–23
Chattahoochee:					
Norcross, Ga.	16	6	6	16.0	6
		15	16	17.3	15
West Point, Ga.	20	1	1	20.3	1
		5	6	22.4	6
		15	17	26.0	15
Columbus, Ga.	20	(1)	----------	45.8	6
				52.8	16
Eufaula, Ala.	40	(1)	10	57.5	7
		15	21	63.8	17
Alaga, Ala.	30	(1)	11	42.5	8
		15	28	46.0	18
Choctawhatchee:					
Newton, Ala.	24	(1)	----------	26.7	1
		----------	----------	[3] 36.0	15
Geneva, Ala.	23	(1)	9	[3] 28.4	2
		15	22	46.1	16
Caryville, Fla.	12	(1)	25	27.1	17
Pea: Pera, Ala.	32	8	8	33.0	8
		14	----------	46.0	15
Conecuh:		1	3	37.2	2
River Falls, Ala.	35	7	8	37.9	8
		15	----------	50.5	15
Brewton, Ala.	13	(1)	29	33.5	15
Alabama:					
Montgomery, Ala.	35	(1)	10	47.8	7
		15	30	56.9	17
Selma, Ala.	35	(1)	(2)	50.4	7–8
				56.2	19
Etowah: Canton, Ga.	11	5	6	13.5	5
		14	15	13.1	15
		22	23	12.8	23
Coosa:		6	7	22.3	7
Gadsden, Ala.	22	16	22	24.9	17
		24	28	23.3	25
Lock 4, Lincoln, Ala.	17	(1)	9	18.6	5
		15	20	21.7	16
Wetumpka, Ala.	45	5	7	47.3	5
		15	19	55.4	15
		22	26	49.6	24
Tallapoosa: Milstead, Ala.	40	15	16	50.9	15
Cahaba: Centerville, Ala.	25	14	16	32.5	14
		22	23	27.5	23
Tombigbee: Lock 4, Demopolis, Ala.	39	(1)	(2)	50.0	6
				65.5	28
Black Warrior: Lock 10, Tuscaloosa, Ala.	46	(1)	2	51.8	1
		6	6	46.3	6
		14	20	62.0	15
		22	27	61.3	24
Pascagoula: Merrill, Miss.	20	15	24	22.4	21
Chickasawahay:					
Enterprise, Miss.	21	14	18	35.0	16
		23	25	31.9	24
Shubuta, Miss.	27	15	29	40.4	17
Leaf: Hattiesburg, Miss.	19	16	18	21.5	17
Pearl:					
Edinburg, Miss.	21	16	20	24.2	17
		22	28	23.2	26
Jackson, Miss.	20	15	(2)	32.2	24, 25
					28, 29
Monticello, Miss.	18	15	16	20.4	15
		26	(2)	20.6	28–31
Columbia, Miss.	18	15	21	22.0	17
		24	(2)	21.8	31
West Pearl: Pearl River, La.	13	(1)	(2)	16.3	17–18

River and station	Flood stage	Above flood stages—dates From—	Above flood stages—dates To—	Crest Stage	Crest Date
GREAT LAKES DRAINAGE					
	Feet			*Feet*	
St. Joseph: Montpelier, Ohio	10	(1)	4	12.5	Feb. 28
		16	18	12.7	17
Saginaw: Saginaw, Mich.	19	17	18	19.4	18
Tittabawassee: Midland, Mich.	18	15	15	18.2	15
Grand:					
Eaton Rapids, Mich.	5	(1)	8	5.6	1
		16	27	5.2	17–19
Grand Ledge, Mich.	7	(1)	7	8.0	Feb. 28–Mar. 1
		17	19	7.0	17–19
Grand Rapids, Mich.	11	6	10	13.9	7
		19	19	11.0	19
Red Cedar:					
Williamston, Mich.	6	(1)	2	7.1	1
East Lansing, Mich.	8	(1)	2	8.3	1
MISSISSIPPI DRAINAGE					
Ohio:					
Dam 25, Point Pleasant, W. Va.	40	1	3	44.7	2
		8	8	40.8	8
Point Pleasant, W. Va.	40	1	4	44.2	2
Dam 29, Normal, Ky.	50	2	3	51.1	2
Portsmouth, Ohio	50	2	4	51.9	3
Dam 33, Maysville, Ky.	48	3	4	49.3	3
Dam 35, Oneonta, Ky.	45	3	5	46.0	4
Dam 36, Cold Spring, Ky.	50	4	4	50.5	4
Cincinnati, Ohio	52	3	5	52.7	4
Dam 38, Grant, Ky.	45	3	10	47.3	4–5
Louisville, Ky.	28	5	6	28.4	5
Dam 41, Louisville, Ky.	51	6	6	51.0	6
Dam 44, Leavenworth, Ind.	50	4	12	53.0	6
Dam 45, Addison, Ky.	45	5	12	46.2	10
Evansville, Ind.	35	2	17	42.1	11
Dam 48, Cypress, Ind.	35	3	17	41.4	11–12
Dam 49, Uniontown, Ky.	40	8	15	41.5	11–12
Shawneetown, Ill.	35	3	19	43.8	11
Dam 50, Fords Ferry, Ky.	35	3	20	44.7	12–13
Dam 51, Golconda, Ill.	38	6	19	42.1	12–13
Paducah, Ky.	43	9	20	45.0	14–15
Dam 52, Brookport, Ill.	43	9	20	44.9	14
Dam 53, Grand Chain, Ill.	43	6	(2)	48.7	19–20
Cairo, Ill.	45	7	(2)	51.9	20
Muskingum: McConnelsville, Ohio	22	(1)	2	25.6	Feb. 28
Tuscarawas: Coshocton, Ohio	8	(1)	2	17.0	Feb. 27
Walhonding: Walhonding, Ohio	8	(1)	1	16.5	Feb. 26
		27	27	9.0	27
Big Sandy, Levisa Fork:					
Pikeville, Ky.	35	23	24	47.6	23
Prestonsburg, Ky.	40	24	24	42.2	24
Scioto:					
Circleville, Ohio	10	(1)	1	18.4	Feb. 27
Chillicothe, Ohio	16	(1)	1	26.5	Feb. 28
Kentucky:					
Hazard, Ky.	20	23	23	23.5	23
Beattyville, Ky.	30	24	25	43.1	24
High Bridge, Ky.	30	26	27	31.2	26
Green River:					
Lock 6, Brownsville, Ky.	30	(1)	2	32.6	Feb. 28
Lock 4, Woodbury, Ky.	33	(1)	4	41.3	2
		26	28	34.9	27
Lock 2, Rumsey, Ky.	34	1	16	39.3	7–9
Wabash:					
Covington, Ind.	16	(1)	1	[3] 17.7	1
Mount Carmel, Ill.	16	1	10	19.8	6
White: Decker, Ind.	18	1	9	21.1	6
White, East Fork:					
Seymour, Ind.	10	(1)	1	14.3	Feb. 27
Williams, Ind.	10	1	5	15.9	2
Shoals, Ind.	20	2	6	26.1	4
White, West Fork:					
Elliston, Ind.	19	(1)	2	21.7	1
Edwardsport, Ind.	15	(1)	4	17.8	1–2
Cumberland:					
Williamsburg, Ky.	22	23	26	30.4	25
Burnside, Ky.	50	23	25	69.4	24
Celina, Tenn.	45	25	29	52.7	27
Carthage, Tenn.	40	24	(2)	55.6	25
Nashville, Tenn.	40	4	6	41.0	6
		24	(2)	50.9	30–31
Clarksville, Tenn.	46	6	8	48.0	7
		26	(2)	53.8	31
Lock F, Eddyville, Ky.	57	9	10	57.2	9–10
		31	(2)	57.8	31
New: New River, Tenn.	25	23	23	41.2	23
Caney Fork: Rock Island, Tenn.	----------	----------	----------	38.8	23
Tennessee:					
Rockwood, Tenn.	20	24	26	27.6	24
Chattanooga, Tenn.	33	24	27	38.7	26
Bridgeport, Ala.	24	25	28	26.5	26
Widows Bar Dam, Ala.	17	1	11	22.4	3
		15	19	21.1	17
		24	30	27.5	27
Guntersville, Ala.	31	26	30	34.8	28
Florence, Ala.	18	16	17	18.9	16–17
		23	(2)	22.8	25
Riverton, Ala.	33	3	(2)	44.6	25–26
Tennessee:					
Savannah, Tenn.	40	24	(2)	44.5	27
Johnsonville, Tenn.	31	17	21	31.9	18
		23	(2)	36.8	29
French Broad:					
Asheville, N. C.	4	5	5	4.6	5
		13	17	5.8	14
Dandridge, Tenn.	12	24	24	12.3	24

[1] Continued from last month.

[2] Continued at end of month.

[3] Estimated.

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
MISSISSIPPI DRAINAGE—continued	*Feet*			*Feet*	
Big Pigeon: Newport, Tenn.	6	5	6	9.8	5
		14	14	6.5	14
		23	23	8.5	23
Clinch:					
Clinton, Tenn.	25	24	26	34.5	24
Kingston, Tenn.	25	24	24	27.0	24
Elk: Fayetteville, Tenn.	14	22	28	[4] 28.0	23
Duck: Columbia, Tenn.	30			43.8	25
Hiwassee: Charleston, Tenn.	22	24	24	22.6	24
Mississippi:					
Muscatine, Iowa.	16	19	[1]	16.7	23
Keokuk, Iowa.	14	16	[2]	19.4	23
Warsaw, Ill.	17	16	[2]	22.0	23
Quincy, Ill.	14	14	[2]	20.5	25
Hannibal, Mo.	13	2	3	13.8	3
		14	[2]	20.4	25
Louisiana, Mo.	12	1	4	13.7	3
		14	[2]	18.4	19
Grafton, Ill.	18	16	[2]	22.9	27
Alton, Ill.	21	17	[2]	25.3	18
Chester, Ill.	27	18	23	28.8	20
Cape Girardeau, Mo.	30	18	[2]	34.1	20
New Madrid, Mo.	34	6	[2]	41.0	21
Cottonwood Point, Mo.	35	11	[2]	37.6	22–23
Memphis, Tenn.	35	11	[2]	40.8	24–25
Helena, Ark.	44	14	[2]	50.4	27
Arkansas City, Ark.	48	18	[2]	53.4	[4] 31
Greenville, Miss.	42	21	[2]	46.3	[4] 31
Vicksburg, Miss.	45	21	[2]	49.6	[4] 31
Natchez, Miss.	46	26	[2]	48.5	[4] 31
Angola, La.	45	31	[2]		
Baton Rouge, La.	35	30	[2]	35.5	[4] 31
Wisconsin: Portage, Wis.	17	24	25	17.5	24
Rock: Moline Bridge, Ill.	11	5	[1]	[3] 14.9	11
				13.4	20
Cedar: Cedar Rapids, Iowa.	14	18	20	20.1	18
Des Moines:					
Boone, Iowa.	20	16	17	20.9	17
Tracy, Iowa.	15	12	22	18.3	16
Ottumwa, Iowa.	10	14	24	14.5	17
Raccoon: Van Meter, Iowa.	13	12	19	18.5	12
Illinois:					
Morris, Ill.	13	4	4	13.2	4
		16	20	17.6	17
		23	23	13.3	23
Peru, Ill.	14	[1]	[2]	21.2	18–19
Henry, Ill.	10	[1]	[2]	16.0	20–21
Peoria, Ill.	18	[1]	[2]	22.5	20–22
Havana, Ill.	14	[1]	[2]	19.4	23–24
Beardstown, Ill.	14	[1]	[2]	20.9	22–25
Pearl, Ill.	12	3	[2]	19.6	27–28
Meramec:					
Pacific, Mo.	11	18	19	13.7	19
Valley Park, Mo.	14	19	19	14.3	19
Bourbeuse: Union, Mo.	12	18	18	13.8	18
St. Francis:					
St. Francis, Ark.	17	[1]	14	21.8	3–4
		18	27	20.4	22
Marked Tree, Ark.	17	16	18	17.0	16–18
Missouri:					
Bismarck, N. Dak.	15	27	28	18.5	27
St. Charles, Mo.	25	17	19	26.4	17
Big Sioux: Akron, Iowa.	12	14	15	17.8	15
Grand:					
Gallatin, Mo.	20	[1]	1	25.3	Feb. 28
		5	9	27.8	8
Chillicothe, Mo.	18	[1]	11	26.4	Feb. 28
		13	17	22.4	14
Brunswick, Mo.	12	16	16	12.2	16
Arkansas: Yancopin, Ark.	29	6	[2]	38.9	30–31
Petit Jean: Danville, Ark.	20	[1]	2	23.0	Feb. 27
White River:					
Georgetown, Ark.	22	4	10	22.8	6–7
DeValls Bluff, Ark.	24	8	10	24.0	8–10
Black:					
Corning, Ark.	11	[1]	27	13.4	1–2
Black Rock, Ark.	14	[1]	22	19.7	5
Cache: Patterson, Ark.	9	3	18	10.1	6–7
YAZOO BASIN					
Yazoo: Yazoo City, Miss.	25	23	[3]	26.1	[4] 31
Tallahatchie: Swan Lake, Miss.	25	4	[2]	31.7	29–31
Sulphur:					
Ringo Crossing, Tex.	20	13	14	20.5	14
Finley, Tex.	24	2	6	25.3	3
PACIFIC DRAINAGE					
Willamette: Harrisburg, Oreg.	10	22	22	10.5	22

[1] Continued from last month.
[2] Continued at end of month.
[3] Estimated.
[4] Still rising at end of month.
[5] Ice gorge.

THE EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, MARCH, 1929

By J. B. KINCER

General summary.—Weather conditions during the first decade were generally unfavorable for field work in most of the South, as wet soil hindered plowing and seeding. Some drying occurred in the eastern Cotton Belt toward the close of the period, but in the main parts of the belt it continued unfavorably wet, except in western sections, where fairly good progress in field work was made. In the interior valleys little work was possible, due to frozen ground or wet soil, but the milder weather in western grazing sections was a great relief for livestock from the previous severe conditions.

During the second decade disastrous floods occurred in the Southeastern States, notably in parts of Georgia, southern Alabama, and some adjoining sections. Much damage by washing and flooding was done, and quite generally in the eastern Cotton Belt rains and wet soil further retarded field operations, with many early prepared fields in parts of the Southeast washed out. Abnormally warm weather in the northern States caused the snow cover to disappear rapidly, while in the Great Plains the soil dried quickly with conditions favorable for field work, although very little had been accomplished in the more northern States. Conditions were mostly favorable for livestock interests in the West, while the rains of the previous decade improved pastures and ranges in California.

The summerlike conditions that prevailed during the last decade in the eastern half of the country caused vegetation to advance rapidly, with early fruit trees blooming as far north as Kentucky and eastern Maryland, and buds swelling in some more northern portions. There was very little improvement in the Southeast, however, for although the temperatures were high and the latter part of the period fair, the soil continued too wet. In more western parts of the Cotton Belt outdoor work made better advance, with corn seeding progressing to southern Oklahoma, but the planting of cotton was still confined to extreme southern Texas and locally in Louisiana.

Small grains.—Winter wheat needed warmth during the first decade in the southern Great Plains, but weather conditions were mostly favorable, except in western Kansas and southwestern Nebraska, where it was too dry. There was some unfavorable thawing and freezing in the eastern belt and some reports of winterkilling were received from the Middle Atlantic section. Wheat continued to look well in the far Northwest and rains in the Southwest were beneficial. With moderate to rather high temperatures during the second decade wheat fields greened up appreciably rather generally, with the entire wheat area cleared of snow and an abundance of moisture generally. Fair to good condition was reported from most places, except for some damage by drifting soil in the southwestern belt and some winterkilling in Pennsylvania; wheat was not doing well in parts of Washington. Growth was markedly stimulated during the last decade by high temperatures and moist soil in most of the principal producing areas. Rain was still needed in western Kansas, and moisture was also inadequate in the Pacific Northwest. Field work was inactive in the

spring wheat area due to unfavorable soil conditions and oat seeding was delayed by wet soil, except in the Plains States.

Miscellaneous crops.—There was some greening of grass in the East during the entire month, but toward the close rapid advance was made. Livestock did well in the northern Great Plains, with some ranging during part of the month, but feeding was again necessary in some parts at the close. Excellent weather prevailed in Wyoming the first of the month, but after the first decade rather unfavorable conditions obtained, with heavy feeding and some losses. Livestock were being fed in most other Rocky Mountain sections, although some greening of the range was reported locally. Moisture was needed in the Southwest, but some improvement of the range was noted; some deterioration of shorn sheep occurred.

Potato planting progressed well during the month and had advanced northward to Long Island at the close; the warm weather the latter part caused truck to make generally rapid advance. Fruit trees advanced in most sections, with peaches in bloom in Maryland and southern Indiana at the close of the month; no widespread frost injury occurred.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The weather over the North Atlantic during March was most unusual in many respects. During the first eight days of the month an extensive area of low pressure covered the region usually occupied by the North Atlantic HIGH, while during this period there was a well-developed HIGH off the coast of northern Europe. This reversal of the normal pressure distribution was responsible for strong easterly gales over the eastern section of the southern steamer lanes in place of the usual westerlies. The number of days with gales was considerably above the normal over the region between the thirty-fifth and fiftieth parallels and the thirtieth and fifty-fifth meridians, while the weather over the eastern section of the northern steamer lanes was comparatively moderate, due to the persistent area of high pressure just referred to.

The number of days with fog was somewhat below the normal over the Grand Banks; considerably above off the American coast between the thirty-fifth and forty-fifth parallels as well as in the western part of the Gulf of Mexico and over Ireland; the middle section of the steamer lanes was comparatively clear.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian). North Atlantic Ocean, March, 1929*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.43	([2])	29.96	30th	28.86	20th.
Belle Isle, Newfoundland	29.67	−0.13	30.24	30th	28.14	7th.
Halifax, Nova Scotia	29.86	−0.04	30.44	12th	28.58	6th.
Nantucket	29.91	−0.09	30.36	11th [3]	28.90	7th.
Hatteras	30.07	+0.04	30.56	11th	29.42	7th.
Key West	30.03	0.00	30.12	11th [3]	29.88	5th.
New Orleans	30.01	−0.02	30.34	10th	29.70	4th.
Cape Gracias, Nicaragua	29.93	−0.05	29.98	10th [3]	29.88	1st.
Turks Island	30.11	+0.09	30.20	23d	30.00	6th.[3]
Bermuda	30.17	+0.14	30.52	12th	29.82	8th.[3]
Horta, Azores	29.93	−0.19	30.54	22d	28.92	5th.
Lerwick, Shetland Islands	30.15	+0.45	30.48	13th	29.64	31st.
Valencia, Ireland	30.20	+0.35	30.56	1st	29.82	20th.
London	30.35	+0.39	30.79	1st	30.08	22d.

[1] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon, or 7 a. m., seventy-fifth meridian time.
[2] No normal available.
[3] And on other dates.

Charts VIII to XIII show the conditions from the 1st to 6th, inclusive, and give an idea of the unusual pressure distribution and weather that prevailed over the greater part of the ocean during this period.

Chart XIII shows the position of two disturbances on the 6th. By the 7th the western LOW was central in Newfoundland and on this day, as well as on the 8th, moderate to strong westerly gales still prevailed west of the fiftieth meridian. The eastern disturbance of the 6th moved but little during the next 24 hours, but had decreased considerably in intensity by the 7th, and comparatively moderate weather was the rule over the greater part of the ocean east of the fiftieth meridian, although there was a moderate gale of limited extent between the twentieth meridian and French coast.

On the 10th a disturbance was central over Newfoundland that moved slowly eastward, and on the 16th was near 47° N., 27° W. From the 12th to 15th moderate to strong gales prevailed over the western and middle sections of the steamer lanes, the storm area at times extending as far south as the thirtieth parallel.

From the 12th to 14th a well-developed depression was over the western part of the Gulf of Mexico, although moderate weather was experienced by vessels in that region.

On the 15th the station at Vera Cruz, Mexico, reported a northerly wind with maximum velocity of 64 miles an hour. This was evidently one of the extremely local "northers" that sometimes occur in these waters, as all reports from vessels near by indicated moderate winds only.

On the 18th Sable Island was near the center of a LOW of limited extent, with moderate to strong northwesterly gales in the southwesterly quadrants. The position of the center of this disturbance on the three following days was approximately as follows: 19th, 44° N., 45° W.; 20th, 47° N., 32° W.; 21st, 52° N., 23° W.

On the 22d there was a disturbance of limited extent near midocean, while the 23d was practically the only day on which no reports of winds of force 7 or over were received.

From the 25th to 28th southerly to westerly gales were prevalent over the middle and eastern sections of the steamer lanes.

On the 29th one of the most severe disturbances of the month was central about 300 miles northeast of Bermuda, of which there was no indication on the previous day; the storm area extended from the twenty-eighth to forty-second parallels, and the fiftieth to seventieth meridians. On the 30th the center was near 40° N., 52° W., while winds of force 7 to 12 were reported from the region north of the thirtieth parallel and west of the fortieth meridian. This LOW moved but little during the next 24 hours, and by the 31st the storm area had diminished considerably in extent.

WATERSPOUT

British steamship *Iroquois*, Capt. William Pritchard; observer, T. M. Mapplebeck; Baton Rouge to London:

March 2, 1929, at 3.30 p. m., L. M. T. in 35° 07′ N., 72° 50′ W. A waterspout passed alongside vessel. Temperature of air 58° F.; water 62° F. Immediately after waterspout wind shifted from SSE. to NNW., and commenced to blow a moderate gale and barometer to rise.

OCEAN GALES AND STORMS, MARCH, 1929

Vessel	Voyage		Position at time of lowest barometer		Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
West Wauna, Am. S. S.	New Orleans	Liverpool	40 23 N	55 10 W	Mar. 1	—, 1	Mar. 3	29.32	SW	NW, 7	NNW	NNW, 11	
Yapalaga, Am. S. S.	do	Glasgow	50 41 N	28 09 W	1	8 p, 1	5	29.28	SE	SE, 7	ESE	ESE, 11	ESE–SE
Grete, Ger. S. S.	Charleston	Bremen	45 50 N	32 30 W	2	3 p, 2	5	28.46	SE	8, 11	E	—, 12	ENE–E–ESE
West Gambo, Am. S. S.	New Orleans	do	36 47 N	71 13 W	2	2 p, 2	3	29.50	SE	SSW, 8	NW	NW, 11	SE–W
Balsam, Am. S. S.	New York	Glasgow	40 28 N	54 40 W	3	3 p, 3	6	29.28	ESE	E, 10	WNW	ENE, 12	ESE–N–NNW
Leopold L. D., Fr. S. S.	Norfolk	Galveston	27 12 N	89 15 W	4	—, 4	5	29.83	SSW	SSW, 6	W	NW, 9	SSW–WNW
Lepanto, Br. S. S.	New York	Hull	47 50 N	25 20 W	4	8 p, 5	5	29.13	ENE	E, —	SSE	E, 10	E–SSE
Baron Nairn, Br. S. S.	Swansea	New York	42 05 N	33 50 W	3	11 a, 5	7	28.85	NW	NW, 8	WNW	NW, 10	NW–WNW
Hanley, Am. S. S.	New York	Canal Zone	34 50 N	73 39 W	4	11 p, 5	6	29.27	S	SW, 11	NW	SW, 11	SW–NW
Sarcoxie, Am. S. S.	Havre	New York	40 23 N	66 54 W	5	8 a, 6	8	28.75	SSW	SSW, —	NW	W, 11	SW–W
Carimare, Fr. S. S.	San Juan	Havre	40 29 N	38 00 W	4	4 p, 6	7	29.07	N	NW, 11	WNW	NW, 11	Steady
American Press, Am. S. S.	New Orleans	Glasgow	37 54 N	66 13 W	7	5 a, 7	9	29.29	SW	SW, 8	NW	SW, 11	
Do	do	do	40 33 N	49 10 W	10	4 p, 10	11	29.98	SSE	SSE, 8	NW	SSE, 11	Steady
München, Ger. S. S.	Bremerhaven	New York	42 00 N	57 36 W	9	8 a, 10	11	29.54	SSW	S, 10	NW	—, 10	S–NW
Wytheville, Am. S. S.	Rotterdam	Boston	45 43 N	54 00 W	10	6 a, 12	12	29.67	S	NW, 10	NNW	NW, 10	W–NNW
Berlin, Ger. S. S.	Bremerhaven	New York	43 04 N	50 51 W	13	10 p, 13	14	29.55	W	W, 8	W	NW, 11	W–WNW
American Press, Am. S. S.	New Orleans	Glasgow	43 39 N	28 26 W	13	Noon, 13	14	28.99	ESE	—, 9	SW	SSE, 12	ESE–SW
Yselhaven, Du. S. S.	Norfolk	Bremen	40 30 N	58 49 W	16	3 a, 17	17	29.45	SW	WSW, 4	W	NW, 9	SW–W
West Cobalt, Am. S. S.	New Orleans	London	43 37 N	38 23 W	18	Mdt, 18	21	29.39	SW	SW, 11	WNW	SW, 12	SW–WNW
West Arrow, Am. S. S.	New York	Antwerp	40 21 N	62 20 W	18	—, 18	19	29.56	WNW	WNW, 7	NW	NW, 9	WNW–NW
Mercier, Belg. S. S.	Antwerp	New York	41 52 N	47 38 W	24	7 p, 24	24	29.38	WSW	SSW, 11	NNW	SSW, 11	
Mississippi, Br. M. S.	Plymouth	do	45 33 N	36 49 W	24	6 a, 25	26	29.42	SW	WSW, —	NNW	SW, 10	SW–W
Exton, Am. S. S.	Alexandria	Boston	41 43 N	39 50 W	27	8 a, 27	28	29.67	SW	SW, 10	NW	SW, 10	SW–NW
Schuykill, Br. M. S.	Hull	Baytown	34 00 N	55 35 W	29	10 p, 29	30	29.17	SE	WSW, 12	NNW	WSW, 12	WSW–WNW
Shickshinny, Am. S. S.	Manchester	Charleston	33 50 N	61 20 W	29	1 a, 29	30	29.18	SW	SW, 11	N	—, 11	SW–NW
Conte Biancamano, Ital. S. S.	Gibraltar	New York	41 32 N	51 08 W	29	2 a, 30	30	29.23	E	NE, 9	N	NE, 12	E–NE–N
NORTH PACIFIC OCEAN													
President Garfield, Am. S. S.	San Francisco	Kobe	33 19 N	135 56 E	Feb. 28	Noon, 1	Mar. 1	29.82	S	W, —	WNW	S, 9	S–W
Milluna, Br. S. S.	Muroran	Portland	46 53 N	170 17 E	Mar. 1	4a, 1	1	29.34	NW	NNW, 8	NW	NNW, 10	
Dalblair, Br. S. S.	Portland	Shanghai	51 45 N	149 50 W	3	12 p, 7	8	29.17	W	NW, 7	NNW	NW, 10	NW–NNW
Kurohime Maru, Jap. S. S.	Vancouver	Yokohama	51 00 N	173 40 W	4	9 p, 4	5			WSW, 8		WSW, 8	
Canadian Seigneur, Br. S. S.	Balboa	Victoria	13 30 N	94 48 W	5	6 a, 5	6	29.84	N	N, 8	NE	ENE, 8	N–NE
Kama Maru, Jap. S. S.	Yokohama	New York	40 18 N	151 38 E	5	2 p, 6	6	29.31	SSE	S, 10	W	SSE, 10	
Arabia Maru, Jap. S. S.	Victoria	Yokohama	52 00 N	165 20 W	5	6 a, 5	6	30.08	W	W, 7	NNW	WNW, 9	
President Madison, Am. S. S.	Yokohama	Seattle	49 58 N	147 48 W	5	Mdt, 8	8	29.36	W	NW, 7	NW	NW, 12	Steady
Protesilaus, Br. S. S.	Vancouver	Yokohama	43 47 N	154 10 E	6	7 p, 6	7	29.39	ESE	SSE, 11	WNW	SSE, 12	SE–S
Paris Maru, Jap. S. S.	do	do	45 05 N	155 00 E	6	10 p, 6	7	29.32	ESE	S, 11	WNW	S, 11	ESE–S–SW
Kohnan Maru, Jap. S. S.	Miike	Vancouver	49 41 N	173 17 W	7	10 p, 8	9	28.65	SE	S, 8	W	SE, 8	SE–S
Manukai, Am. S. S.	San Francisco	Hawaii	34 15 N	133 41 W	8	4 p, 8	9	29.57	S	SSW, 4	WNW	W, 8	S–SSW
Olympia Maru, Jap. M. S.	Yokohama	Seattle	49 55 N	168 50 W	8	2 a, 9	11	28.86	S	SW, 9	W	SW, 9	
Golden Dragon, Am. S. S.	San Francisco	Yokohama	34 20 N	169 00 W	11	3 a, 11	11	29.86	SW	SW, 7	WNW	WSW, 8	SW–W
Anyo Maru, Jap. S. S.	Sydney	do	30 53 N	140 52 E	11	Mdt, 11	12	29.52	WSW	W, 10	NW	W, 10	WSW–WNW
Tacoma, Am. S. S.	Manila	San Francisco	35 00 N	143 00 E	11	8 p, 11	12	29.24	WNW	WNW, —	NE	NNW, 10	NNW–NE
Stanley Dollar, Am. S. S.	Nagasaki	Seattle	43 40 N	163 20 E	12	12 p, 12	14	28.45	E	NNE, 10	WNW	WNW, 11	NNE–NW
Hakushika Maru, Jap. S. S.	Miike	Victoria	49 36 N	178 23 E	13	6 a, 14	14	28.83	SE	S, 7	N	SE, 9	SE–S
Kurohime Maru, Jap. S. S.	Vancouver	Yokohama	41 00 N	149 40 E	14	6 p, 14	15	28.40	NW	W, 7		NW, 10	
Tacoma, Am. S. S.	Manila	San Francisco	40 30 N	153 30 E	14	4 a, 15	16	28.80	WNW	W, —	W	W, 10	Steady
Etna Maru, Jap. S. S.	Miike	Portland	49 29 N	147 40 W	16	8 p, 16	17	29.71	S	SSE, 8	SE	SSE, 8	S–SE
Golden Dragon, Am. S. S.	San Francisco	Yokohama	34 00 N	170 00 E	16	6 p., 16	21	29.58	WSW	WSW, 7	WSW	S, 10	
Bintang, Du. M. S.	Dutch East Indies.	Los Angeles	33 36 N	150 04 E	19	4 p, 20	22	29.49	S	WSW, 5	WNW	S, 9	SW–WNW
Yogen Maru, Jap. S. S.	Miike	Columbia	43 49 N	159 17 E	19	2 a, 21	22	29.17	S	WSW, 6	W	WSW, 8	Steady
Dalblair, Br. S. S.	Portland	Shanghai	45 30 N	152 20 E	20	2 a, 21	21	28.64	NW	WSW, 10	WNW	W, 10	W–WNW
Siberia Maru, Jap. S. S.	Yokohama	Honolulu	26 38 N	169 10 W	21	5 p, 21	21	29.23	NNE	NW–SW	S	N, 9	8 pts
Golden Dragon, Am. S. S.	San Francisco	Yokohama	34 22 N	150 00 E	23	3 p, 23	25	29.68	SW	W, 8	NNE	SW, 8	SW–W

NORTH PACIFIC OCEAN

By WILLIS E. HURD

During March pressure increased over that of February in the central Aleutian region and decreased in the Gulf of Alaska, where the Aleutian cyclone was central this month, average minimum pressure 29.59 inches, at Kodiak. During the first two decades of the month the disturbance was strongly developed in the gulf, especially from the 5th to the 10th, when it extended farthest southward between the Hawaiian Islands and the American mainland, and was at its greatest depth in northern waters, lowest pressures at the island stations being about 28.80 inches on the 9th and 10th. After the 20th the cyclone began to disintegrate and the decreasing remnant to retreat northward until, at the end of the month, it no longer affected North Pacific weather.

The California-Pacific anticyclone on the average covered an unusually large area for March in middle and lower latitudes, pressures being generally above normal throughout the whole region so dominated.

Barometric data for several island and mainland coast stations in west longitudes are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, at indicated hours, North Pacific Ocean, and adjacent waters, March, 1929*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow [1]	30.01	-------	30.78	4th	29.16	30th.
Dutch Harbor [1 2]	29.76	+0.03	30.54	31st	28.76	9th.
St. Paul [1 3]	29.80	+0.05	30.44	31st	28.80	9th.
Kodiak [1 3]	29.59	−0.16	30.16	22d [6]	28.84	10th.
Midway Island [1]	30.16	+0.08	30.46	4th	29.84	17th.
Honolulu [4]	30.04	0.00	30.13	13th	29.91	20th.
Juneau [4]	29.74	−0.20	30.27	30th	29.14	11th.
Tatoosh Island [4 5]	30.03	+0.05	30.32	1st	29.40	9th.
San Francisco [4 5]	30.08	+0.03	30.41	26th	29.68	10th.
San Diego [4 5]	30.04	+0.02	30.25	25th	29.78	22d.

[1] P. m. observations only.
[2] For 30 days.
[3] For 29 days.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.
[6] And on 29th.

Fewer stormy days occurred on the North Pacific during March than in any other month since September, 1928. These were principally confined to the first three weeks, the only gales of later date thus far reported by seamen being two of moderate force on the 23d and 25th east of Japan. The principal storm region of the month lay west of the one hundred and eightieth meridian and north of the thirtieth parallel, but strong gales occurred immediately south and southeast of the Aleutian Islands from the 5th to the 10th, and the wind attained hurricane force on the 7th near 50° N., 160° W. Most of the heavy weather in this locality resulted from the steepness of the gradients on the western side of the Aleutian cyclone center, the gales largely increasing in force with rising pressure. Farther westward toward the Japanese coast the rough weather principally resulted from several rather intense cyclones that traveled eastward from Siberia, accompanied by frequent severe snow squalls. From these sources storm to hurricane velocities were encountered east of the Kuril Islands on the 6th, and near 43° N., 160° to 170° E., on the 12th and 13th. On the 20th and 21st the British steamer *Dalblair*, just east of the Kurils, ran into a deep storm, accompanied by whole gales and snows. Under stress of the bad weather the vessel hove to for more than 24 hours, head to the abnormally high westerly seas. Along the upper steamer routes between Japan and longitude 170° E. about 20 to 25 per cent of the days had gales.

From the 20th to the 22d a cyclone of near tropical nature occurred to the westward of the Hawaiian Islands, with pressure observed as low as 29.18 inches, read on board the Japanese steamer *Siberia Maru*, on the 21st, in 26° 38′ N., 169° 10′ W. Gales of force 8 to 9, the highest reported, were experienced between latitudes 20° and 30° N., longitudes 165° to 175° W., on the 21st and 22d, in connection with this storm, which seems to have come in from the southward, although it did not progress greatly during the three days it was under observation. It filled in east of Midway Island, but at no time, despite its great central depth, did it more than slightly affect the barometer at that station or at Honolulu.

No gales were reported by vessels in American coast waters, except on the 5th, when a norther of force 8 was experienced in the Gulf of Tehuantepec and on the 25th and 27th when the Weather Bureau station at Tatoosh Island, Wash., recorded gales of force 9 on the 25th and 27th.

The weather at Honolulu during March was abnormally dry and warm, with less wind than usual for the month. The prevailing direction was from the east, and the maximum velocity was at the rate of 25 miles an hour from the northeast on the 4th.

Fog was less frequent than in February, and was reported on one day only in east longitudes. About 10 to 15 per cent of the days had fog over the region between 35° and 50° N., 145° W. and the American coast, where it was general from the 18th to 20th, and about the same percentage was encountered to 170° west longitude by vessels on northern routes. Fog was reported on three days at St. Paul in the Bering Sea; on six days off the coast of southern California and the upper part of the adjoining peninsula, and on two days near 7°–8° N., 85°–88° W. at some distance from the Panama coast.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, March, 1929

Section	Temperature							Precipitation					
			Monthly extremes							Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	59.6	+3.5	4 stations	93	24	Valley Head	20	10	15.35	+9.60	Elba	33.85	Madison	8.77
Arizona	51.1	−1.4	Parker	98	30	Bright Angel (Ranger Station.)	−2	[2]1	0.46	−0.65	Pinal Ranch	2.43	5 stations	0.00
Arkansas	55.7	+3.0	Harrison	98	24	Dutton	19	[2]1	3.77	−0.97	Clinton	6.27	Cotter	1.35
California	49.4	−1.2	Dudley	98	2	Helm Creek	−18	25	2.35	−1.50	Fordyce Dam	8.70	4 stations	0.00
Colorado	34.7	−0.2	Canon City	84	6	Hermit	−29	1	1.48	+0.15	Trout Lake	6.08	Cope	0.02
Florida	69.1	+3.3	Orlando	95	24	2 stations	34	[2]3	3.21	+0.26	Bluff Springs	19.41	Mammoth Grove	0.45
Georgia	60.4	+3.7	3 stations	94	[2]24	Clayton	16	11	10.17	+5.38	Goat Rock	20.32	Savannah	2.74
Idaho	36.0	0.0	Parma	75	28	Big Springs	−12	31	1.46	−0.18	Roland	5.10	Aberdeen	0.18
Illinois	47.0	+6.4	Harrisburg	94	24	Waukegan	2	7	3.39	+0.18	Golden	7.00	Roberts	1.54
Indiana	47.6	+6.9	3 stations	91	[2]24	Rochester	6	7	3.11	−0.75	La Porte	5.84	Logansport	1.33
Iowa	39.1	+4.5	Keosauqua	83	24	Mason City	−5	9	1.44	−0.33	Wever	4.92	Sac City	0.30
Kansas	46.9	+3.1	2 stations	92	24	Tribune	9	1	0.94	−0.54	Lyndon	3.10	2 stations	T.
Kentucky	52.0	+5.7	Hopkinsville	94	24	2 stations	9	10	4.17	−0.52	Middlesboro	10.20	St. John	1.94
Louisiana	63.4	+2.7	Ruston	95	24	Robeline	25	2	6.00	+1.39	Winnsboro	11.53	Lake Charles	2.38
Maryland-Delaware	48.2	+5.6	Western Port, Md.	86	24	Friendsville, Md.	4	10	3.17	−0.49	Public Landing, Md	5.40	Frostburg, Md.	1.90
Michigan	35.9	+6.2	Monroe	75	25	Humboldt	−22	8	2.07	−0.15	Morenci	4.13	Vanderbilt (near)	0.83
Minnesota	31.0	+4.9	Taylors Falls	70	29	2 stations	−30	9	1.00	−0.11	New Ulm	2.31	Milan	0.22
Mississippi	60.2	+3.4	Macon	96	24	Port Gibson	24	2	8.65	+2.92	Hickory	15.33	Austin	3.84
Missouri	48.6	+4.7	Jefferson City	97	24	Seymour	11	10	3.30	+0.28	Monroe City	6.13	Grant City	0.47
Montana	34.3	+4.1	Medicine Lake	75	28	Cascade	−11	24	1.20	+0.31	Trout Creek	4.10	Kinread	0.08
Nebraska	40.5	+4.9	2 stations	83	24	Gordon	2	25	0.80	−0.30	Hay Springs	3.76	Alma	0.00
Nevada	41.0	0.0	Logandale	86	29	Millett	1	24	0.84	+0.03	Mahoney Ranger Station.	2.57	2 stations	0.00
New England	35.2	+2.9	Bridgeport, Conn.	78	22	Pittsburgh (a), N. H.	−33	11	3.41	+0.18	Somerset, Vt.	5.93	Presque Isle, Me.	1.43
New Jersey	44.9	+6.4	Pleasantville	81	22	Culvers Lake	5	10	3.07	−0.84	Chatham	4.92	Hightstown	1.92
New Mexico	42.3	−1.2	Artesia	87	24	Elizabethtown	−26	1	0.94	+0.08	Levy	3.26	Animas	0.00
New York	38.2	+6.2	Mount Hope	78	22	McKeever	−26	10	3.21	+0.15	South Edwards	6.00	Chazy	1.03
North Carolina	54.1	+4.2	2 stations	91	24	Mount Mitchell	0	10	5.94	+1.66	Rock House	14.16	Manteo	1.58
North Dakota	30.5	+7.9	Carson	77	29	2 stations	−15	[2]7	0.78	−0.05	Mott	3.00	Pembina	0.00
Ohio	45.8	+6.6	Ironton	92	25	Hiram	3	8	2.83	−0.60	Dam No. 28, Ohio River.	4.53	North Bass Island	1.38
Oklahoma	53.3	+2.2	2 stations	97	[2]6	Boise City	9	1	3.42	+1.25	Chickasha	6.72	Boise City	0.97
Oregon	43.0	+0.8	Grants Pass	81	4	Austin	0	4	2.64	−0.68	Government Camp	10.39	2 stations	T.
Pennsylvania	43.7	+6.2	Vandergrift	89	25	Montrose	−5	9	2.60	−0.85	Warren	4.50	Ebensburg	1.37
South Carolina	57.6	+2.8	2 stations	93	25	2 stations	20	11	7.59	+3.61	Caesars Head	12.57	Charleston	2.05
South Dakota	36.0	+5.1	do	75	28	Pollock	−5	6	1.78	+0.67	Harveys Ranch	4.25	Flandreau	0.33
Tennessee	54.3	+4.8	Clarksville	94	24	Elkmont	11	10	7.75	+2.40	Rock Island	14.64	Memphis	3.63
Texas	61.0	+2.3	Riogrande	102	23	Vega	10	1	2.58	+0.52	Bon Wier	8.62	2 stations	0.05
Utah	37.8	−0.6	St. George	83	29	Beaver	−7	25	1.62	+0.12	Morgan	7.45	Otter Creek Reservoir.	0.12
Virginia	50.6	+4.8	Pedlar Dam	93	25	Burkes Garden	5	10	3.97	+0.24	Pedlar Dam	6.10	Staunton	2.08
Washington	42.1	+1.2	Trinidad	73	18	Bumping Lake	9	31	3.39	−0.17	Mt. Baker Lodge	17.74	Wahluke	T.
West Virginia	46.7	+3.9	2 stations	92	25	Pickens	−2	10	3.47	−0.42	Camden-on-Gauley.	6.65	Morgantown	1.27
Wisconsin	32.8	+3.6	Lancaster	69	14	Long Lake	−22	9	1.65	−0.06	Plum Island	3.56	Grantsburg	0.57
Wyoming	29.6	+0.1	Cody	72	28	Moran	−23	22	1.75	+0.68	Sundance	4.29	Deaver	0.32
Alaska (February)	18.2	+7.5	Lignite	52	14	Eagle	−49	22	2.86	+1.05	Latouche	19.90	McKinley Park	0.04
Hawaii	70.0	+1.4	Waipahu	92	[2]28	Volcano Observatory.	46	7	7.55	−2.30	Honomu	40.71	6 stations	0.00
Porto Rico	74.0	+0.2	Canovanas	94	10	Guineo Reservoir	49	8	4.75	+1.21	Rio Grande	12.08	Ponce	0.54

[1] For description of tables and charts, see REVIEW, January, 1929, p. 36.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1929*

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F	°F.	°F	%	In.	In.		Miles								0–10	In.	In.
New England							37.6	+4.8										75	3.48	0.0										6.0		
Eastport	76	67	85	29.75	29.84	−0.09	31.0	+2.1	52	31	38	−4	11	24	28	29	24	74	3.11	−0.7	17	8,062	s.	36	nw.	8	4	13	14	7.0	24.0	1.8
Greenville, Me	1,070	6	----	28.66	29.86	------	27.0	------	55	19	36	−15	11	17	45	----	----	----	2.05	------	12	------	nw.	----	----	18	11	9	11	----	19.0	----
Portland, Me	103	82	117	29.78	29.90	−.06	35.6	+3.8	61	12	43	3	11	28	36	31	26	71	3.41	−0.4	12	6,568	sw.	36	nw.	6	14	8	12	5.4	5.9	0.0
Concord	289	70	79	29.56	29.89	−.11	35.6	+4.8	63	12	45	3	10	26	44	----	----	----	3.78	+0.8	12	4,419	nw.	24	nw.	9	11	9	11	5.3	5.3	0.0
Burlington	403	11	48	29.44	29.89	−.11	32.8	+3.7	59	19	41	−1	10	25	30	----	----	----	2.47	+0.4	14	8,316	s.	39	s.	21	3	7	21	7.8	4.5	0.0
Northfield	876	12	60	28.93	29.91	−.09	31.5	+5.1	59	12	41	−8	10	22	48	29	25	82	2.54	0.0	14	5,779	s.	28	sw.	22	3	11	17	7.5	12.9	0.0
Boston	125	115	188	29.75	29.89	−.08	41.4	+5.8	69	22	50	9	10	33	33	36	30	69	2.80	−0.8	11	7,136	sw.	34	sw.	7	12	6	13	5.8	4.0	0.0
Nantucket	12	14	90	29.88	29.89	−.09	39.9	+4.4	62	13	47	12	10	33	23	37	34	83	4.66	+0.9	16	11,231	sw.	55	ne.	2	11	5	15	6.4	1.9	0.0
Block Island	26	11	46	29.86	29.89	−.09	39.9	+4.5	64	22	46	12	10	34	24	37	34	82	4.59	+0.8	15	12,555	sw.	54	w.	7	12	7	12	5.1	2.0	0.0
Providence	160	215	251	29.73	29.91	−.07	41.6	+5.9	73	22	50	8	10	33	33	36	29	67	3.17	−0.3	13	8,666	nw.	45	nw.	7	12	5	14	5.3	5.2	0.0
Hartford	159	122	----	29.74	29.92	−.07	41.6	+6.6	73	22	51	8	10	32	30	----	----	----	3.52	−0.4	15	------	sw.	----	----	----	14	7	10	4.7	3.9	0.0
New Haven	106	74	153	29.82	29.94	−.05	42.4	+6.6	75	22	51	10	10	33	35	38	33	74	4.19	+0.1	15	6,509	s.	35	nw.	8	11	11	9	5.2	1.6	0.0
Middle Atlantic States							47.2	+6.7										69	2.84	−0.6										5.6		
Albany	97	107	115	29.82	29.92	−.09	38.8	+6.1	64	16	48	6	10	30	43	34	29	72	3.10	+0.5	15	5,407	sw.	30	s.	25	10	9	12	5.7	5.2	0.0
Binghamton	871	10	84	28.98	29.93	−.09	40.9	+8.3	68	23	50	7	10	31	34	----	----	----	2.03	−0.6	14	4,564	nw.	34	sw.	7	3	12	16	7.1	3.2	0.0
New York	314	414	454	29.61	29.95	−.05	44.8	+7.1	75	22	54	12	10	36	28	39	32	66	3.51	−0.1	12	13,166	nw.	60	nw.	7	10	12	9	5.7	0.3	0.0
Bellefonte, Pa	1,050	5	36	28.83	29.96	------	40.8	------	75	24	53	7	10	28	43	36	31	72	1.83	------	9	------	w.	----	----	----	8	9	14	6.2	7.1	0.0
Harrisburg	374	94	104	29.57	29.98	−.05	45.8	+6.9	78	24	55	13	10	36	35	39	32	63	2.19	−0.8	11	5,306	sw.	33	sw.	7	10	9	12	5.8	5.0	0.0
Philadelphia	114	123	367	29.85	29.98	−.04	48.4	+7.6	78	22	58	14	10	39	30	43	38	72	2.22	−1.2	10	10,662	sw.	48	nw.	7	10	9	12	5.7	T.	0.0
Reading	325	81	98	29.61	29.96	------	46.6	------	75	22	56	13	10	37	32	41	34	67	2.66	−0.9	10	5,150	nw.	32	nw.	7	11	9	11	5.3	3.0	0.0
Scranton	805	111	119	29.08	29.96	−.06	42.4	+6.7	72	22	52	7	10	33	34	37	33	74	1.95	−1.2	14	5,382	sw.	33	w.	7	4	10	17	7.4	4.4	0.0
Atlantic City	52	37	172	29.92	29.98	−.04	45.9	+7.3	79	22	54	13	10	38	34	40	36	75	3.25	−0.4	12	13,672	sw.	52	w.	7	13	7	11	4.8	T.	0.0
Cape May	17	13	49	----	----	------	46.6	+5.8	78	24	55	15	10	38	33	42	38	79	3.14	------	13	------	s.	----	----	----	13	7	11	----	T.	0.0
Sandy Hook	22	10	55	29.92	29.94	------	43.5	------	74	22	51	14	10	36	26	39	34	76	2.38	−1.7	15	10,743	nw.	51	w.	7	9	12	10	5.3	T.	0.0
Trenton	190	159	183	29.75	29.96	------	46.0	------	77	22	56	11	10	36	30	40	34	68	2.34	−1.1	12	8,234	sw.	43	nw.	7	12	7	12	5.6	T.	0.0
Baltimore	123	100	215	29.85	29.98	−.05	50.2	+7.9	83	24	60	16	10	40	34	43	35	63	3.16	−0.6	11	7,908	sw.	54	sw.	7	14	6	11	5.3	T.	0.0
Washington	112	62	85	29.86	29.98	−.06	50.2	+7.6	84	24	60	15	10	40	38	43	34	60	2.64	−1.1	9	5,422	s.	40	nw.	7	14	5	12	5.4	T.	0.0
Cape Henry	18	8	54	29.99	30.01	------	54.2	------	87	26	64	25	10	45	33	47	42	69	3.36	−0.5	7	9,588	sw.	50	nw.	7	11	11	9	5.1	0.0	0.0
Lynchburg	681	153	188	29.26	30.01	−.04	52.8	+5.5	87	24	64	20	10	42	35	44	37	60	3.22	−0.3	10	6,388	sw.	40	nw.	7	13	10	8	4.8	0.0	0.0
Norfolk	91	170	205	29.93	30.03	.00	54.4	+6.2	86	24	64	21	10	45	31	47	41	66	2.80	−1.0	8	11,368	s.	61	w.	7	11	9	11	5.2	0.0	0.0
Richmond	144	11	52	29.87	30.02	−.02	52.8	+5.6	87	24	63	18	10	42	35	45	39	66	3.96	+0.3	10	7,027	sw.	40	nw.	7	11	11	9	5.2	T.	0.0
Wytheville	2,304	49	55	27.62	30.01	−.04	47.6	+5.3	84	25	58	14	10	37	36	41	35	68	3.51	+0.1	15	5,341	w.	35	w.	16	9	7	15	5.7	3.2	0.0
South Atlantic States							58.5	+4.8										73	4.67	+0.9										5.3		
Asheville	2,253	70	84	27.66	30.04	−.02	50.4	+5.5	87	25	60	20	10	40	36	43	37	69	5.85	+1.9	13	7,342	se.	36	nw.	7	12	13	6	4.8	0.4	0.0
Charlotte	779	55	62	29.20	30.04	−0.1	55.8	+5.4	90	25	66	26	10	46	35	48	42	68	7.09	+2.9	13	4,636	sw.	33	nw.	7	9	12	10	5.5	0.0	0.0
Greensboro	886	5	56	29.09	30.05	------	51.9	------	87	25	64	19	11	40	42	45	40	73	4.34	------	12	7,007	sw.	42	sw.	23	10	9	12	5.5	0.0	0.0
Hatteras	11	11	50	30.04	30.04	.00	56.6	+4.6	78	24	63	30	11	50	26	53	49	78	2.41	−1.8	12	10,672	s.	48	nw.	7	12	10	9	4.8	0.0	0.0
Raleigh	376	103	110	29.64	30.04	−.01	55.6	+5.4	88	24	66	23	10	45	32	49	44	73	6.00	+2.1	12	6,516	sw.	35	nw.	7	9	11	11	5.8	0.0	0.0
Wilmington	78	81	91	29.99	30.08	+.03	58.9	+5.6	87	24	68	28	10	50	26	54	50	78	2.06	−1.1	10	6,483	s.	28	w.	2	9	13	9	5.2	0.0	0.0
Charleston	48	11	92	30.01	30.06	.00	61.4	+4.0	88	24	69	38	10	54	26	55	51	74	2.05	−1.0	10	8,628	sw.	37	w.	5	9	13	9	5.4	0.0	0.0
Columbia, S. C	351	41	57	29.67	30.06	.00	58.9	+3.7	91	24	69	31	10	49	29	52	48	74	5.27	+1.9	13	5,698	s.	42	sw.	23	10	15	6	4.9	0.0	0.0
Due West	711	10	55	29.29	30.07	------	56.2	------	88	25	66	29	10	46	33	----	----	----	10.94	------	13	6,906	sw.	40	w.	5	8	10	13	5.6	0.0	0.0
Greenville, S. C	1,039	139	146	28.93	30.04	------	55.1	+5.2	88	25	64	27	10	46	30	48	42	68	9.03	+3.9	14	6,506	ne.	40	sw.	5	9	9	13	5.8	0.0	0.0
Augusta	182	62	77	29.84	30.03	−.03	61.0	+5.0	93	25	71	34	3	51	33	53	47	67	6.72	+2.6	14	4,430	nw.	34	w.	5	10	14	7	5.2	0.0	0.0
Savannah	65	150	194	29.99	30.06	.00	63.2	+4.2	92	24	72	38	6	54	27	56	52	75	2.74	−0.3	10	9,539	s.	48	w.	5	9	12	10	5.6	0.0	0.0
Jacksonville	43	209	245	30.00	30.05	−.01	66.8	+4.2	89	27	75	43	6	58	27	59	55	74	2.14	−0.8	10	8,778	s.	47	sw.	23	11	9	11	5.3	0.0	0.0
Florida Peninsula							73.0	+3.2										77	2.91	+0.9										4.2		
Key West	22	10	64	30.00	30.02	−.03	75.7	+3.1	85	16	81	57	7	71	17	69	67	78	1.25	−0.1	6	7,236	se.	36	nw.	5	18	7	6	3.5	0.0	0.0
Miami	25	71	164	30.03	30.06	−.03	72.9	+2.7	85	16	79	48	6	67	27	67	65	79	5.31	+3.1	11	7,950	se.	41	sw.	5	11	10	10	5.3	0.0	0.0
Tampa	35	79	87	30.01	30.05	−.02	70.5	+3.7	89	25	79	51	6	62	26	62	59	75	2.18	−0.2	7	4,699	e.	24	e.	12	9	11	11	5.1	0.0	0.0
Titusville	44	5	----	30.00	30.05	------	----	----	91	28	----	45	7	62	----	----	----	----	0.63	------	6	------	se.	----	----	----	19	12	0	2.7	0.0	0.0
East Gulf States							61.4	+3.9										72	10.95	+5.8										5.2		
Atlanta	1,173	190	216	28.79	30.04	−.02	56.8	+4.8	87	24	66	32	10	48	32	50	44	68	13.28	+8.0	13	8,745	nw.	41	nw.	5	10	9	12	5.8	T.	0.0
Macon	370	78	87	29.65	30.05	−.01	60.6	+3.9	92	24	71	33	3	50	33	54	49	71	10.89	+5.9	7	5,005	s.	26	sw.	5	9	12	10	5.5	0.0	0.0
Thomasville	273	49	58	29.75	30.05	−.01	64.5	+4.3	92	24	75	40	11	54	35	56	51	70	5.48	+1.4	10	3,876	sw.	26	sw.	5	10	11	10	5.5	0.0	0.0
Apalachicola	36	42	49	30.01	30.05	------	63.8	------	81	28	70	45	11	58	20	59	56	79	5.24	+1.0	9	6,458	se.	28	w.	5	13	11	7	4.2	0.0	0.0
Pensacola	56	149	185	29.97	30.03	−.03	63.0	+2.7	82	23	68	41	10	58	19	58	55	79	6.42	+1.6	8	10,357	s.	51	s.	14	13	9	9	4.9	0.0	0.0
Anniston	741	9	57	29.24	30.04	−.02	57.8	+5.3	90	24	69	29	10	46	39	----	----	----	12.58	+6.9	14	4,895	se.	20	nw.	5	13	7	9	4.9	0.0	0.0
Birmingham	700	11	48	29.26	30.02	−.04	59.4	+4.0	89	24	69	30	10	50	34	51	44	65	13.14	+7.4	14	6,358	se.	31	se.	13	9	12	10	5.2	0.0	0.0
Mobile	57	125	161	29.95	30.01	−.05	63.6	+3.9	89	23	71	40	2	56	24	57	54	79	20.23	+14.2	9	7,603	s.	34	sw.	23	9	14	8	5.1	0.0	0.0
Montgomery	223	100	112	29.78	30.03	−.03	61.8	+4.0	90	24	71	35	10	53	30	55	50	70	15.38	+9.4	11	5,397	se.	24	e.	15	11	12	8	4.8	0.0	0.0
Corinth	469	6	----	----	----	------	57.2	------	92	24	68	28	10	47	35	----	----	----	9.30	------	11	------	s.	----	----	----	6	21	4	----	----	----
Meridian	375	87	95	29.60	30.00	−.05	60.8	+3.7	93	24	71	33	10	50	33	53	47	68	13.70	+8.5	10	4,711	sw.	28	w.	23	9	14	8	5.4	0.0	0.0
Vicksburg	247	65	78	29.72	30.00	−.04	61.2	+2.7	92	24	71	34	10	52	29	54	48	69	8.86	+3.3	11	5,387	se.	29	nw.	4	10	12	9	5.0	0.0	0.0
New Orleans	53	76	84	29.94	30.00	−.04	66.2	+3.4	90	23	74	43	10	58	24	60	57	80	6.25	+1.5	8	5,090	se.	22	sw.	23	9	9	13	5.7	0.0	0.0
West Gulf States							62.2	+3.0										72	2.85	+0.1										5.2		
Shreveport	249	77	93	29.68	29.96	−.06	61.6	+3.3	91	23	71	35	2	52	31	53	47	67	3.08	−1.0	9	5,006	se.	22	s.	6	14	9	8	4.8	0.0	0.0
Bentonville	1,303	11	44	28.54	29.91	−.10	51.0	+3.7	89	24	61	27	1	41	33	----	----	----	2.05	------	13	------	s.	----	----	31	16	7	8	----	0.0	0.0
Fort Smith	457	79	94	29.44	29.93	−.08	55.0	+2.4	92	24	65	30	2	45	37	49	44	73	5.45	+2.4	12	6,126	e.	32	w.	4	13	7	11	5.5	0.0	0.0
Little Rock	357	136	153	29.57	29.95	−.08	56.8	+3.8	90	24	66	31	2	47	33	49	43	66	4.72	+0.1	17	6,860	sw.	40	nw.	31	8	7	16	6.5	0.0	0.0
Austin	605	136	148	29.28	29.91	------	63.9	+3.2	92	23	74	36	2	53	37	56	51	70	3.62	+1.3	13	5,676	se.	35	nw.	12	9	13	9	5.3	0.0	0.0
Brownsville	57	83	100	29.83	29.89	------	71.0	+2.8	90	12	79	43	2	63	27	64	61	80	0.26	−1.0	5	9,026	s.	33	s.	3	13	14	4	3.9	0.0	0.0
Corpus Christi	20	11	78	29.89	29.91	−.07	68.6	+3.6	87	23	74	51	5	63	25	63	60	81	1.06	−0.5	5	9,207	se.	32	nw.	4	8	12	11	5.6	0.0	0.0
Dallas	512	220	227	29.38	29.93	------	60.4	------	90	23	70	37	5	50	35	----	----	----	2.43	−0.4	6	9,597	se.	38	ne.	7	14	9	8	4.1	0.0	0.0
Fort Worth	670	106	114	29.19	29.90	−.08	60.8	+3.1	91	23	72	38	2	50	38	52	45	62	1.39	−0.9	5	7,061	s.	30	w.	4	8	13	10	5.5	0.0	0.0
Galveston	54	106	114	29.91	29.97	−.04	64.4	+2.0	79	29	69	45	2	60	16	60	58	86	3.57	+0.9	6	7,730	se.	28	nw.	4	10	13	8	5.0	0.0	0.0
Groesbeck	461	11	56	29.44	29.93	------	61.7	------	89	23	72	35	2	52	33	----	----	----	2.31	−0.3	11	7,653	s.	40	s.	31	11	14	6	4.9	0.0	0.0
Houston	138	292	314	29.81	29.96	------	64.9	+1.6	89	23	73	41	2	57	27	----	----	----	2.33	−1.2	7	9,181	se.	33	w.	4	8	9	14	5.7	0.0	0.0
Palestine	510	64	72	29.41	29.94	−.06	61.8	+2.7	92	23	72	34	2	52	34	55	50	71	3.21	−0.3	8	5,883	s.	28	s.	31	10	11	10	5.1	0.0	0.0
Port Arthur	34	58	66	29.92	29.96	------	64.8	------	82	26	72	41	1	58	21	----	----	----	1.60	------	7	5,459	se.	30	e.	12	9	11	11	5.4	0.0	0.0
San Antonio	693	119	132	29.18	29.91	−.07	65.8	+3.0	94	23	76	38	2	56	39	57	50	65	3.12	+1.3	11	4,570	ne.	27	nw.	4	9	14	8	5.1	0.0	0.0
Taylor	583	55	63	29.35	29.96	−.03	63.0	+3.3	92	23	74	32	2	52	39	----	----	----	3.30	+1.2	12	6,003	s.	32	s.	31	9	16	6	5.0	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*° F.*	*° F.*	*° F*		*° F*	*° F.*		*° F*	*° F*	*° F*	*° F*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							59.2	+5.9										68	3.84	−0.3										6.1		
Chattanooga	762	190	215	29.20	30.02	−0.04	55.6	+4.4	89	24	65	25	10	46	36	47	39	61	10.80	+5.0	17	6,514	se.	34	nw.	5	8	9	14	5.8	0.1	0.0
Knoxville	995	102	111	28.96	30.02	−.04	53.3	+4.6	88	25	63	24	10	44	34	47	42	72	6.69	+1.6	16	5,155	sw.	34	sw.	6	7	9	15	6.1	T.	0.0
Memphis	399	76	97	29.54	29.97	−.07	56.2	+3.9	86	24	64	29	10	49	25	49	44	67	3.63	−1.6	14	5,722	sw.	46	w.	31	9	10	12	5.9	0.0	0.0
Nashville	546	168	191	29.43	30.02	−.03	54.4	+5.2	88	24	64	23	10	45	36	47	40	64	6.48	+1.4	11	7,579	s.	38	nw.	6	7	12	12	5.8	1.5	0.0
Lexington	989	193	230	28.93	30.01	−.04	49.4	+5.7	86	25	59	15	10	40	34				3.67	−0.6	13	10,889	sw.	42	w.	16	11	11	9	5.1	7.5	0.0
Louisville	525	188	234	29.41	30.00	−.05	51.5	+6.1	88	24	61	19	10	42	33	45	39	67	2.30	−2.1	11	8,678	s.	38	w.	6	10	13	8	5.1	1.0	0.0
Evansville	431	76	116	29.53	30.00	−.04	51.4	+5.5	87	24	60	23	10	43	28	45	40	69	2.52	−1.7	13	7,590	s.	36	sw.	15	8	12	11	5.8	0.0	0.0
Indianapolis	822	194	230	29.06	29.96	−.06	47.2	+7.2	83	24	57	17	10	38	35	41	35	68	3.24	−0.7	15	8,999	s.	45	nw.	6	6	13	12	6.2	T.	0.0
Royal Center	736	11	55	29.14	29.95	------	44.4	------	75	24	54	12	10	35	38				3.87	+0.9	13	8,449	sw.	44	w.	6	6	10	15	6.6	T.	0.0
Terre Haute	575	96	129	29.32	29.95	------	48.8	------	85	24	58	17	10	39	38	42	38	73	3.63	−0.1	13	7,880	s.	38	nw.	6	9	11	11	6.0	0.2	0.0
Cincinnati	627	11	51	29.29	29.98	−.07	49.2	+8.3	88	25	58	16	10	40	34	43	37	69	2.51	−1.4	14	6,280	sw.	37	nw.	6	6	14	11	6.0	1.2	0.0
Columbus	822	179	222	29.09	29.97	−.07	47.4	+8.3	84	25	56	16	10	39	28	42	37	73	1.76	−1.7	14	8,123	s.	60	nw.	6	7	14	10	6.1	0.4	0.0
Dayton	899	137	173	29.00	29.96	------	47.7	+7.2	84	25	56	16	10	39	32	42	36	70	2.45	−1.2	14	7,535	sw.	46	nw.	6	4	17	10	6.5	0.5	0.0
Elkins	1,947	59	67	27.93	30.02	−.03	44.4	+4.4	86	25	58	7	10	31	44	38	33	72	3.42	−0.4	16	4,645	w.	36	w.	7	6	7	18	7.2	8.7	0.0
Parkersburg	637	77	82	29.34	30.00	−.05	48.4	+5.6	89	25	60	12	10	37	38	41	34	66	2.39	−1.1	14	4,641	se.	36	sw.	7	8	9	14	6.0	4.4	0.0
Pittsburgh	842	353	410	29.05	29.97	−.07	46.4	+6.8	84	25	56	11	10	37	33	39	33	64	2.15	−0.9	16	8,604	sw.	50	w.	7	4	10	17	6.9	3.1	0.0
Lower Lake Region							40.9	+7.9										74	2.96	+0.3									7.0		
Buffalo	767	247	280	29.06	29.91	−.11	38.1	+7.0	65	25	47	7	9	30	29	34	30	78	2.38	−0.2	21	13,375	sw.	74	w.	7	2	11	18	7.6	5.7	0.0
Canton	448	10	61	29.39	29.88	------	32.7	+5.0	58	19	41	−3	10	24	33				3.93	+1.4	21	7,395	sw.	36	sw.	19	5	10	16	6.8	7.3	0.0
Ithaca	836	5	100	29.00	29.92	------	39.3	------	66	23	49	5	10	30	34	34	30	75	2.78	+0.5	18	7,749	nw.	33	se.	25	4	11	16	7.3	8.1	0.0
Oswego	335	76	91	29.53	29.90	−.11	38.3	+7.1	68	23	46	9	8	31	34	34	30	76	2.76	+0.2	20	7,465	s.	34	sw.	7	2	6	23	8.1	7.4	0.0
Rochester	523	86	102	29.34	29.92	−.10	40.5	+8.7	70	25	49	8	9	32	36	35	29	70	2.43	−0.3	17	6,617	sw.	45	sw.	7	2	13	16	7.4	5.0	0.0
Syracuse	596	65	79	29.28	29.93	−.09	41.0	+9.6	68	23	50	10	10	32	34				2.51	−0.5	16	5,869	s.	24	sw.	7	2	13	16	7.4	6.1	0.0
Erie	714	130	166	29.15	29.94	−.08	42.2	+8.7	76	25	51	11	9	33	33	37	32	73	3.05	+0.4	18	10,809	sw.	58	sw.	6	3	17	11	6.4	2.5	0.0
Cleveland	762	190	201	29.11	29.94	−.09	43.6	+9.0	80	25	53	13	10	34	37	39	33	70	3.54	+0.8	17	9,959	sw.	64	w.	6	5	11	15	6.9	1.2	0.0
Sandusky	629	5	67	29.26	29.95	−.08	43.9	+8.8	78	25	53	14	10	34	36				3.01	+0.3	19	7,281	sw.	38	sw.	6	3	13	15	6.8	0.9	0.0
Toledo	628	208	243	29.25	29.94	−.09	43.3	+8.0	76	25	52	11	7	34	38	38	34	73	2.76	+0.2	20	10,650	sw.	56	w.	7	9	13	9	5.6	0.6	0.0
Fort Wayne	856	113	124	29.00	29.94	------	44.5	+5.6	75	25	53	12	7	36	35	39	35	75	3.57	+0.4	15	7,255	sw.	39	w.	7	5	10	16	6.7	0.3	0.0
Detroit	730	218	258	29.12	29.92	−.11	41.7	+8.3	74	25	51	10	7	33	38	37	34	80	2.85	+0.4	18	8,446	sw.	48	w.	6	6	11	14	6.5	2.4	0.0
Upper Lake Region							34.3	+6.1										79	2.48	+0.3									6.4		
Alpena	609	13	92	29.21	29.89	−.14	33.0	+7.5	61	18	42	0	8	24	35	30	26	78	1.96	0.0	13	8,442	nw.	40	nw.	6	9	7	15	6.1	9.3	4.0
Escanaba	612	54	60	29.21	29.90	−.14	29.2	+5.0	59	27	37	−3	9	21	32	26	23	82	1.41	−0.5	12	7,233	s.	36	nw.	7	11	8	12	5.7	5.5	1.5
Grand Haven	632	54	89	29.21	29.91	−.12	37.2	+5.5	67	25	44	8	7	30	32	34	31	82	2.32	−0.1	13	9,073	s.	60	w.	6	4	14	13	6.7	0.3	T.
Grand Rapids	707	70	87	29.13	29.92	−.11	39.6	+8.2	66	12	48	9	7	32	37	35	30	73	2.06	−0.4	14	4,854	w.	36	nw.	6	4	13	14	6.5	1.8	0.0
Houghton	668	64	99	29.13	29.87	−.17	27.4	+4.6	57	29	36	−6	9	19	43				3.85	+1.8	16	6,637	e.	42	nw.	6	4	7	20	7.5	23.9	T.
Lansing	878	6	49	28.96	29.92	------	39.4	+7.2	66	25	49	9	7	30	37	35	32	83	3.15	+0.8	14	5,143	sw.	34	w.	7	8	10	13	6.2	4.2	0.0
Ludington	637	60	66	29.18	29.89	------	35.0	------	55	23	41	8	7	29	27	32	29	84	1.64	−0.6	12	7,896	s.	42	nw.	6	5	9	17	6.9	6.0	3.4
Marquette	734	77	111	29.06	29.84	−.20	30.1	+5.3	58	27	38	1	9	22	31	27	24	82	1.84	−0.4	16	6,939	w.	36	nw.	6	5	4	22	7.5	12.2	T.
Port Huron	638	70	120	29.20	29.91	−.12	38.8	+8.4	71	25	48	9	8	30	35	34	31	78	1.97	−0.1	17	8,860	sw.	52	w.	6	3	20	8	5.8	1.6	0.0
Sault Sainte Marie	614	11	52	29.18	29.90	−.13	28.1	+6.5	55	29	36	−11	9	21	38	26	23	84	2.08	+0.2	15	6,007	se.	31	nw.	30	4	14	13	6.8	8.7	T.
Chicago	673	7	131	29.18	29.92	−.11	43.2	+7.9	71	24	52	9	7	35	36	37	32	71	5.23	+2.6	9	8,712	sw.	39	nw.	6	7	12	12	6.1	0.7	0.0
Green Bay	617	109	141	29.21	29.88	−.16	33.4	+4.8	61	27	42	1	7	25	32	30	27	81	2.11	+0.1	11	8,356	s.	44	ne.	31	6	12	13	6.3	8.5	6.0
Milwaukee	681	125	221	29.15	29.90	−.13	38.0	+5.9	65	27	46	1	7	30	33	34	29	73	3.32	+0.9	9	10,182	w.	41	nw.	6	7	11	13	6.2	4.2	1.8
Duluth	1,133	5	47	28.62	29.87	−.19	28.3	+4.6	57	29	36	−10	7	20	36	25	21	79	1.79	+0.2	10	8,976	sw.	53	nw.	6	9	8	14	6.1	11.1	0.0
North Dakota							30.6	+8.2										78	1.10	+0.3									6.0		
Moorhead	940	50	58	28.83	29.87	−.21	30.9	+8.2	64	28	40	−5	7	22	39	28	24	80	1.01	0.0	7	6,210	n.	26	nw.	6	7	9	15	6.8	7.1	0.0
Bismarck	1,674	8	57	28.04	29.86	−.20	32.2	+8.0	67	28	41	5	7	23	33	28	24	77	1.61	+0.7	10	6,721	nw.	34	w.	29	7	14	10	5.8	6.2	T.
Devils Lake	1,478	11	44	28.24	29.86	−.19	28.6	+8.8	66	28	38	−2	7	19	35	25	22	83	0.76	0.0	11	6,983	ne.	32	nw.	29	8	11	12	5.5	6.5	0.0
Ellendale	1,457	10	56	28.27	29.86	------	32.7	------	66	28	41	0	9	24	38				0.78	0.0	11	10,062	nw.	49	nw.	6	6	12	13	6.4	3.8	0.0
Grand Forks	833	12	67	------	------	------	29.0	------	63	28	39	−6	7	19	42	26	----	----	0.85	------	8	------	s.	----	s.	28	5	7	19	----	1.5	0.0
Williston	1,878	41	48	27.84	29.86	−.18	30.8	+7.9	67	28	40	3	6	22	38	28	23	74	1.32	+0.6	7	6,012	w.	37	w.	29	10	10	11	5.4	11.8	0.3
Upper Mississippi Valley							41.9	+5.8										73	2.88	+0.6									6.2		
Minneapolis	918	102	208	28.85	29.85	------	34.2	+4.6	60	29	42	−3	7	26	34				1.31	−0.1	9	8,040	nw.	41	nw.	6	6	9	16	6.5	4.4	0.6
St. Paul	837	236	261	28.95	29.88	−.17	33.2	+4.1	58	27	41	−3	7	25	31				1.29	−0.1	8	8,216	nw.	40	nw.	6	4	11	16	6.8	3.8	0.7
La Crosse	714	11	48	29.10	29.89	−.15	36.0	+4.5	61	27	44	2	7	28	31	32	27	75	1.85	+0.2	7	3,896	s.	20	nw.	6	6	10	15	6.7	6.3	6.0
Madison	974	70	78	28.84	29.92	−.12	35.6	+5.0	64	27	43	1	7	28	29	32	28	78	2.30	+0.2	9	6,912	sw.	31	nw.	7	9	6	16	6.3	8.0	3.7
Wausau	1,247	4	64	28.52	29.89	------	31.6	------	58	29	40	−2	7	24	25				2.40	+0.6	8	4,678	w.	26	nw.	6	18	5	8	6.5	12.3	5.7
Charles City	1,015	10	51	28.81	29.91	−.14	34.2	+3.5	60	27	43	1	9	25	31	31	28	80	1.67	−0.1	6	5,330	se.	28	nw.	6	8	11	12	5.7	5.9	4.7
Davenport	606	71	79	29.24	29.90	−.13	43.4	+7.3	74	24	52	12	7	34	36	38	34	75	2.60	+0.3	12	8,679	sw.	50	nw.	6	8	9	14	6.1	0.5	0.0
Des Moines	861	84	97	28.98	29.90	−.14	40.8	+4.9	73	24	50	10	9	32	38	36	31	74	1.11	−0.7	5	5,429	sw.	28	sw.	18	6	10	15	6.5	0.7	0.0
Dubuque	700	81	96	29.14	29.90	−.14	38.6	+4.6	64	18	47	7	7	30	30	34	29	71	2.41	+0.4	9	5,013	s.	32	nw.	6	8	7	16	6.5	2.7	0.3
Keokuk	614	64	78	29.24	29.93	−.10	46.0	+7.1	81	24	56	16	9	36	38	39	34	69	4.78	+2.4	9	5,788	s.	34	w.	6	7	7	17	6.6	T.	0.0
Cairo	358	87	93	29.59	29.98	−.06	52.9	+5.7	88	24	61	26	10	45	25	47	41	71	3.54	−0.2	13	7,314	s.	37	sw.	31	8	7	16	6.3	T.	0.0
Peoria	609	11	45	29.26	29.93	−.10	45.4	+8.4	81	24	56	17	7	35	40	39	35	74	4.57	+1.8	9	5,895	s.	33	nw.	6	13	10	8	4.7	T.	0.0
Springfield, Ill.	636	154	191	29.24	29.92	−.11	47.2	+7.0	84	24	57	20	10	38	40	41	36	72	2.96	−0.2	7	9,847	s.	47	nw.	6	8	8	15	6.3	T.	0.0
Hannibal	534	74	109	29.34	29.92	−.10	48.0	+7.0	87	24	58	19	9	38	41				5.11	+2.5	8	6,979	sw.	32	w.	6	9	8	14	5.9	T.	0.0
St. Louis	568	265	303	29.32	29.93	−.10	50.8	+7.0	92	24	61	22	10	41	40	44	38	68	5.33	+2.0	11	9,995	s.	40	nw.	6	12	8	11	5.3	T.	0.0
Missouri Valley							43.4	+5.8										68	1.82	0.0									5.4		
Columbia, Mo.	784	6	84	29.08	29.92	−.11	48.5	+5.9	89	24	60	19	9	38	41				4.05	+1.1	8	6,093	s.	36	nw.	6	9	10	12	6.1	T.	0.0
Kansas City	963	161	181	28.87	29.92	−.10	48.2	+5.5	87	24	58	19	9	39	39	41	34	62	3.28	+0.8	4	7,514	s.	42	nw.	31	11	11	9	5.1	T.	0.0
St. Joseph	967	11	49	28.86	29.90	------	46.4	------	86	24	56	17	9	37	43	39	32	63	1.98	−0.1	7	6,235	sw.	34	nw.	6	14	7	10	4.6	T.	0.0
Springfield, Mo.	1,324	98	104	28.53	29.94	−.08	49.4	+4.2	91	24	59	25	10	40	38	43	37	69	2.97	−0.4	13	7,948	s.	30	se.	12	10	10	11	5.5	T.	0.0
Iola	984	11	50	28.85	29.91	−.10	49.4	+4.9	89	24	61	24	9	38	40				1.55	−1.1	9	4,922	s.	25	n.	6	7	13	11	5.8	0.0	0.0
Topeka	987	92	107	------	------	------	48.0	+5.4	88	24	58	22	9	38	45				2.01	−0.1	7	7,067	sw.	40	nw.	6	11	10	10	5.3	0.3	0.0
Lincoln	1,189	11	81	28.61	29.89	−.13	42.6	+5.1	69	27	52	21	9	33	37	36	29	65	0.08	−1.2	2	7,196	s.	38	nw.	6	9	9	13	5.6	T.	T.
Omaha	1,105	115	122	28.70	29.90	−.14	42.4	+5.4	68	27	51	14	9	34	32	36	28	63	0.54	−0.8	4	5,864	nw.	34	nw.	6	11	11	9	5.2	1.5	T.
Valentine	2,598	47	54	27.13	29.88	−.15	37.9	+5.6	71	10	49	13	1	27	40	32	26	69	2.56	+1.5	11	7,344	w.	36	sw.	10	10	14	7	5.2	17.4	4.0
Sioux City	1,135	94	164	28.66	29.90	−.15	39.6	+6.9	68	29	49	13	9	30	33	34	29	70	1.12	0.0	8	9,165	nw.	51	nw.	6	8	15	8	5.7	7.1	4.2
Huron	1,306	59	74	28.46	29.89	−.17	36.4	+7.5	67	28	45	11	7	27	35	32	28	76	1.50	+0.6	10	6,949	nw.	33	nw.	6	9	13	9	5.5	5.9	T.
Pierre	1,572	70	75	------	29.88	−.17	38.6	+7.1	71	28	49	16	7	28	37	----	----	79	1.28	0.0	12	6,476	nw.	36	nw.	6	11	7	13	----	5.6	0.5
Yankton	1,233	49	57	28.53	29.87	−.18	39.6	+6.4	70	29	50	15	9	30	39	----	----	----	0.79	−0.5	8	6,230	w.	33	nw.	6	9	11	11	5.7	6.0	5.0

TABLE 1.—*Climatological data for Weather Bureau stations, March, 1929*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F		°F	°F	°F	°F	%	In.	In.		Miles								0–10	In.	In.
Northern Slope							35.0	+3.7										67	1.38	+0.4											6.0	
Billings	3,140	5					37.4		72	28	50	10	14	25	41				1.06		9		nw.				15	2	14		10.4	1.0
Havre	2,505	11	44	27.20	29.87	−0.13	36.4	+9.3	73	28	48	8	6	25	41	32	27	71	0.85	+0.3	6	5,685	sw.	32	sw.	26	6	12	13	6.5	5.7	T.
Helena	4,110	87	112	25.66	29.91	−.10	36.4	+4.0	66	28	45	5	24	28	34	31	24	62	1.14	+0.4	9	6,820	sw.	32	sw.	1	5	9	17	6.8	15.3	0.0
Kalispell	2,973	48	56	26.81	29.90	−0.9	35.8	+2.9	55	27	43	16	24	28	27	32	26	70	0.63	−0.3	8	3,796	nw.	25	sw.	5	5	13	13	6.5	1.8	0.0
Miles City	2,371	48	55	27.32	29.91	−.11	36.7	+8.1	71	28	46	14	15	28	33	32	26	71	1.72	+0.9	13	5,291	s.	33	nw.	29	7	14	10	6.0	9.7	0.0
Rapid City	3,259	50	58	26.43	29.90	−.11	36.6	+4.0	72	28	47	12	25	26	41	31	23	60	2.69	+1.7	11	6,298	n.	34	n.	29	10	11	10	5.3	24.1	4.0
Cheyenne	6,088	84	101	23.83	29.90	−.06	32.6	−0.5	58	29	42	6	1	23	32	27	19	60	1.51	+0.5	13	11,048	w.	44	w.	1	10	5	16	6.1	15.1	T.
Lander	5,372	60	68	24.49	29.92	−.07	32.4	0.0	61	28	44	5	1	21	35	28	24	72	1.36	+0.2	7	3,787	se.	50	nw.	29	14	12	5	4.3	9.9	T.
Sheridan	3,790	10	47	25.95	29.91		34.6		66	28	46	8	15	24	39	29	24	70	2.56	+1.4	13	4,611	nw.	32	nw.	1	8	14	9	5.7	24.1	4.0
Yellowstone Park	6,241	11	48	23.73	29.97	−.05	28.2	+1.7	52	27	38	5	31	18	34	24	19	69	1.03	−0.6	14	6,178	sw.	34	sw.	5	5	7	19	6.9	9.8	T.
North Platte	2,821	11	51	26.92	29.87	−.13	40.4	+3.8	74	29	53	12	1	28	39	33	25	62	0.28	−0.6	7	6,080	w.	29	n.	4	7	13	11	5.8	0.9	0.0
Middle Slope							46.2	+2.9										57	1.86	+0.2									5.08		
Denver	5,292	106	113	24.57	29.87	−.08	39.8	+0.5	70	29	50	16	14	29	32	32	22	53	2.16	+1.1	11	4,933	s.	31	nw.	11	10	12	9	5.7	24.8	T.
Pueblo	4,685	80	86	25.14	29.85	−.07	42.6	+1.0	76	29	56	12	1	29	50	34	22	49	0.30	−0.3	5	5,600	nw.	40	w.	2	12	11	8	5.2	2.9	0.0
Concordia	1,392	50	58	28.43	29.92	−.09	46.1	+5.1	73	24	57	22	1	35	41	38	30	62	0.06	−1.2	3	6,047	s.	31	s.	11	4	10	17	6.9	T.	0.0
Dodge City	2,509	11	51	27.30	29.93	−.04	46.4	+3.6	84	24	60	19	1	33	53	36	27	55	0.48	−0.4	1	7,072	nw.	33	se.	11	16	6	9	4.4	T.	0.0
Wichita	1,358	139	158	28.45	29.90	−.09	49.1	+4.0	85	24	59	27	1	39	40	41	33	60	0.88	−0.9	6	8,689	s.	33	s.	11	8	15	8	5.8	0.0	0.0
Broken Arrow	765	11	56	29.10	29.92		52.4		89	24	62	28	1	42	36				4.13	+0.3	9	9,703	s.	36	se.	12	5	11	15	6.6	0.0	0.0
Oklahoma City	1,214	10	47	28.62	29.91	−.07	53.1	+3.1	91	24	64	27	1	42	36	44	36	62	5.05	+3.1	8	7,811	s.	26	s.	2	9	9	13	6.0	T.	0.0
Southern Slope							55.6	+1.0										54	1.52	+0.6									4.6		
Abilene	1,738	10	52	28.10	29.90	−.06	57.8	+1.3	92	24	69	33	1	47	41	48	38	56	2.72	+1.4	8	6,840	s.	29	s.	2	11	7	13	5.2	0.0	0.0
Amarillo	3,676	10	49	26.16	29.90	−.05	48.9	+2.0	82	6	62	18	1	36	47	39	30	56	1.84	+1.1	4	6,734	w.	27	w.	12	10	14	7	4.7	0.0	0.0
Del Rio	944	64	71	28.88	29.86	−.09	65.7	+2.2	95	31	77	38	1	54	43	54	44	55	0.72	0.0	9	6,276	se.	39	nw.	3	16	8	7	4.2	0.0	0.0
Roswell	3,566	75	85	26.27	29.88	−.02	49.8	−1.5	83	6	64	17	1	35	50	39	26	47	0.80	+0.1	2	5,949	sw.	30	sw.	24	12	14	5	4.4	0.0	0.0
Southern Plateau							50.4	−0.4										44	0.21	−0.3									3.6		
El Paso	3,778	152	175	26.11	29.89	+.01	54.4	−1.4	81	30	66	25	1	42	37	40	22	34	0.21	−0.2	1	8,981	w.	48	w.	11	18	12	1	3.2	0.0	0.0
Santa Fe	7,013	38	53	23.12	29.88	−.01	37.8	−1.9	67	29	49	−1	1	27	38	30	19	52	0.59	−0.2	5	4,614	n.	27	sw.	23	10	13	8	5.3	10.4	0.0
Flagstaff	6,907	10	59	23.25	29.88	−.03	35.5	−0.4	64	29	48	2	25	22	41	30		68	1.10		7		nw.		s.	23	10	19	2		1.5	0.0
Phoenix	1,108	10	107	28.75	29.91	.00	60.4	−0.3	86	30	75	34	25	46	38	45	27	33	0.13	−0.6	2	4,173	e.	27	sw.	10	17	6	8	3.5	0.0	0.0
Yuma	141	9	54	29.78	29.94	.00	63.0	−1.1	93	29	78	37	25	48	44	48	29	33	0.02	−0.3	1	4,161	w.	27	n.	26	20	11	0	2.4	0.0	0.0
Independence	3,957	6	27	25.93	29.96	+.02	51.4	+2.9	81	29	66	22	24	37	39	37			0.08	−0.4	3		nw.				14	13	4		0.0	0.0
Middle Plateau							40.5	−0.4										56	0.98	−0.1									5.0		
Reno	4,532	74	81	25.44	30.01	+.03	42.4	+1.4	72	4	55	14	24	30	42	35	26	56	0.67	−0.1	6	4,437	w.	36	w.	10	14	8	9	4.9	1.5	0.0
Tonopah	6,090	12	20				39.2		66	28	48	16	24	30	24	32	21	50	0.20		3		nw.									
Winnemucca	4,344	18	56	25.60	30.02	+.01	39.2	−0.8	69	5	54	11	31	24	46	34	26	61	0.55	−0.4	5	4,878	sw.	28	sw.	5	16	13	7	5.9	0.5	0.0
Modena	5,473	10	43	24.53	29.90	−.06	38.8	+0.6	68	29	52	10	25	26	41	31	20	53	0.68	−0.4	5	7,345	w.	58	sw.	10	11	10	10	4.8	2.8	0.0
Salt Lake City	4,360	163	203	25.56	29.97	−.01	40.3	−1.4	63	28	48	23	25	32	28	34	28	62	1.96	0.0	11	4,626	nw.	34	nw.	21	9	7	13	6.4	10.3	0.0
Grand Junction	4,602	60	68	25.29	29.88	−.06	41.6	−2.0	69	29	52	17	1	31	34	33	23	52	1.02	+0.3	8	3,885	n.	31	s.	11	10	12	9	5.1	2.5	0.0
Northern Plateau							42.3	+0.8										63	0.86	−0.4									6.2		
Baker	3,471	48	53	26.41	30.03	.00	37.8	+0.2	61	27	47	20	30	28	31	33	27	65	0.47	−0.6	10	4,364	se.	23	sw.	5	7	13	11	6.2	1.2	0.0
Boise	2,739	78	86	27.14	30.02	−.01	42.8	+0.1	66	28	52	25	31	34	28	37	30	62	1.41	+0.1	8	4,005	se.	28	nw.	28	9	6	16	6.5	3.9	0.0
Lewiston	757	40	48	29.18	30.00	−.03	46.4	+1.0	69	9	57	30	14	36	33				1.01	−0.1	11	2,922	e.	27	sw.	5	7	10	14	6.2	0.3	0.0
Pocatello	4,477	60	68	25.39	29.96	−.05	37.6	+0.2	59	28	46	20	14	29	28	32	25	65	0.82	−0.5	11	6,788	sw.	36	sw.	2	5	14	12	6.2	6.0	0.0
Spokane	1,929	101	110	27.90	29.98	−.03	41.7	+2.0	60	15	50	24	30	33	32	37	30	66	0.91	−0.3	10	4,709	sw.	28	sw.	26	9	6	16	6.4	2.0	0.0
Walla Walla	991	57	65	28.93	30.01	−.01	47.7	+1.6	72	27	56	32	23	39	27	41	32	58	0.56	−1.0	10	4,042	s.	28	w.	21	9	10	12	5.9	0.4	0.0
North Pacific Coast Region							45.6	+0.4										76	3.20	−0.5									7.2		
North Head	211	11	56	29.87	30.10	+.09	44.6	−0.6	54	19	48	36	22	41	12	43	42	91	5.57	0.0	25	10,197	s.	54	s.	25	4	12	15	7.0	0.0	0.0
Port Angeles	29	8	53		30.06		42.9		55	18	49	31	14	36	21				1.54	−0.6	11	4,137	sw.	30	w.	21	3	12	16		T.	0.0
Seattle	125	215	250	29.92	30.05	+.06	45.0	+0.1	60	14	51	33	30	39	25	42	39	79	2.73	−0.3	15	6,160	s.	32	s.	5	4	7	20	7.6	T.	0.0
Tacoma	194	172	201	29.85	30.06	+.06	45.2	+1.0	63	19	52	32	18	39	29				4.00	+0.5	17	5,887	sw.	35	sw.	21	2	13	16	7.2	T.	0.0
Tatoosh Island	86	9	53	29.93	30.03	+.07	44.0	+1.1	52	18	47	37	29	41	11	43	41	91	6.40	−1.4	21	9,797	s.	54	s.	27	6	6	19	7.3	0.0	0.0
Yakima	1,076	58	67	28.83	29.99		45.0		67	3	56	26	12	34	34	38	29	56	0.45	+0.1	5	3,938	nw.	35	nw.	21	10	6	15	5.9	T.	0.0
Medford	1,425	4	80	28.56	30.08		45.8		76	4	59	22	29	33	46	40	33	66	0.93		7		nw.		se.	9	1	16	14	7.0	2.0	0.0
Portland, Oreg.	153	68	106	29.93	30.09	+.07	47.7	+0.8	66	19	55	33	12	41	26	44	39	73	2.90	−1.0	16	3,712	nw.	22	w.	28	2	2	27	8.5	0.2	0.0
Roseburg	510	75	99	29.56	30.12	+.06	46.8	−0.3	74	4	56	30	29	37	37	43	38	74	2.02	−1.3	15	2,384	nw.	21	nw.	28	1	13	17	7.5	0.3	0.0
Middle Pacific Coast Region							52.8	0.0										70	1.44	−1.9									4.9		
Eureka	62	73	89	30.08	30.15	+.09	47.6	−0.7	73	4	54	34	24	42	28	45	42	81	2.31	−2.9	11	4,685	n.	31	n.	30	9	6	16	6.3	0.0	0.0
Red Bluff	330	54	58	29.69	30.05	+.01	54.6	+1.0	84	3	66	33	11	43	33	47	37	57	1.26	−2.0	6	4,096	nw.	28	nw.	21	11	7	13	5.7	0.0	0.0
Sacramento	69	106	117	29.97	30.04	+.01	54.1	−0.2	80	3	65	36	25	43	31	49	43	72	0.78	−1.8	5	5,303	se.	27	se.	9	16	8	7	3.6	0.0	0.0
San Francisco	155	208	243	29.91	30.08	+.02	54.2	0.0	81	3	61	43	24	48	25	48	43	71	1.56	−1.6	7	5,621	w.	34	w.	22	12	10	9	4.8	0.0	0.0
San Jose	141	12	110	29.92	30.08		53.4	−0.3	83	4	65	33	25	42	38				1.31	−1.3	5	4,446	nw.	31	w.	22	13	10	8	4.3	0.0	0.0
South Pacific Coast Region							56.1	−0.3										69	1.75	−0.3									4.3		
Fresno	327	89	98	29.70	30.06	+.05	55.4	+0.4	84	4	67	34	25	44	33	48	40	62	1.53	0.0	7	3,847	nw.	27	nw.	22	16	9	6	4.0	0.2	0.0
Los Angeles	338	159	191	29.67	30.04	+.02	57.2	−0.3	79	4	66	40	24	48	30	50	44	68	2.51	−0.3	4	3,835	sw.	22	nw.	13	13	10	8	4.2	0.0	0.0
San Diego	87	62	70	29.94	30.04	+.02	55.6	−1.1	75	1	62	42	25	49	27	50	47	76	1.22	−0.5	9	4,645	w.	24	w.	13	13	10	8	4.7	0.0	0.0
West Indies																																
San Juan, P. R.	82	9	54	29.94	30.02		75.2	−0.2	83	10	80	67	17	70	13				2.47	−0.7	20	10,073	e.	36	e.	15	8	19	4	5.0	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[1]29.76	[1]29.84	.00	80.9	−0.3	92	5	90	70	17	72	20			[2]74	2.19	+1.4	3	6,824	nw.	25	nw.	25	4	15	12	6.2	0.0	0.0
Cristobal	38	7	97	[1]29.84	[1]29.87	−.01	81.7	+0.2	88	1	86	74	8	77	13	74	72	[2]79	2.59	+1.1	12	9,787	n.	30	nw.	6	4	19	8	6.1	0.0	0.0
Alaska																																
Juneau	80	11	50	[1]29.65	[1]29.74		35.1		47	23	39	21	6	31	16	33	30	80	6.15		24	5,711	e.	30	e.	13	2	3	26	8.3	22.6	3.8
Hawaiian Islands																																
Honolulu	38	86	100	[1]30.00	[1]30.04		72.9		80	22	78	64	6	68	13	66	63	72	0.28	−2.9	7	5,542	e.	25	ne.	4	8	17	6	5.2	0.0	0.0

[1] Pressure not reduced to mean of 24 hours.

[2] Observations taken bihourly.

TABLE 2.—*Data furnished by the Canadian Meterological Service, March, 1929*

Stations	Altitude above mean sea level, Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*Inches*	*Inches*	*Inches*	°F.	°F.	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
Cape Race, N. F.	99				25.3		32.6	18.0	44	2	5.41		2.6
Sydney, C. B. I.	48	29.76	29.81	−0.07	26.6	+0.4	36.1	17.2	51	−10	2.66	−2.27	14.0
Halifax, N. S.	88	29.75	29.86	−.08	30.7	+1.7	38.8	22.7	53	0	2.35	−3.11	8.3
Yarmouth, N. S.	65												
Charlottetown, P. E. I.	38	29.72	29.76	−.14	26.8	+1.4	34.3	19.4	50	−9	3.53	+0.32	25.3
Chatham, N. B.	28	29.70	29.73	−.17	24.9	+1.9	34.8	15.0	52	−13	2.27	−1.20	9.6
Father Point, Que.	20												
Quebec, Que.	296	29.55	29.88	−.08	25.6	+4.4	31.9	19.4	47	−12	2.47	−0.79	13.4
Doucet, Que.	1,236				16.2		28.1	4.3	43	−38	0.62		6.2
Montreal, Que.	187	29.65	29.87	−.13	30.0	+6.2	36.6	23.4	53	−2	5.93	+2.14	16.2
Ottawa, Ont.	236	29.62	29.90	−.11	30.1	+8.6	37.7	22.5	52	−4	3.18	+0.46	10.8
Kingston, Ont.	285	29.58	29.90	−.11	33.3	+7.7	39.8	26.8	50	2	3.01	+0.37	3.4
Toronto, Ont.	379	29.48	29.90	−.12	36.9	+9.6	44.4	29.3	65	4	3.42	+0.78	3.2
Cochrane, Ont.	930				16.4		26.4	6.4	50	−27	1.98		17.4
White River, Ont.	1,244	28.50	29.85	−.18	18.4	+6.2	30.4	6.4	48	−36	1.95	+0.57	13.5
London, Ont.	808				37.6		46.8	28.3	69	4	3.81		5.3
Southampton, Ont.	656	29.16	29.89	−.14	32.9	+8.2	40.8	25.0	55	0	3.32	+0.67	12.0
Parry Sound, Ont.	688	29.17	29.88	−.14	30.0	+8.9	37.2	22.8	50	−13	3.70	+1.47	13.3
Port Arthur, Ont.	644	29.16	29.89	−.16	25.8	+9.0	34.0	17.6	55	−12	1.62	+0.65	9.0
Winnipeg, Man.	760												
Minnedosa, Man.	1,690	28.00	29.87	−.19	21.3	+8.8	31.6	11.0	64	−23	0.58	−0.07	5.8
Le Pas, Man.	860				15.1		28.8	1.5	57	−35	1.58		15.8
Qu'Appelle, Sask.	2,115	27.54	29.83	−.21	25.1	+10.2	34.6	15.6	68	−16	0.46	−0.31	4.6
Moose Jaw, Sask.	1,759				30.3		41.8	18.9	64	−5	0.75		6.0
Swift Current, Sask.	2,392	27.23	29.78	−.24	32.5	+10.5	43.9	21.2	67	−4	0.55	−0.26	3.8
Medicine Hat, Alb.	2,144												
Calgary, Alb.	3,428												
Banff, Alb.	4,521												
Prince Albert, Sask.	1,450	28.28	29.92	−.16	18.9	+6.9	31.7	6.1	61	−29	0.82	+0.05	7.4
Battleford, Sask.	1,592	28.08	29.86	−.20	26.9	+13.8	38.4	15.4	62	−16	0.12	−0.34	1.0
Edmonton, Alb.	2,150												
Kamloops, B. C.	1,262												
Victoria, B. C.	230	29.77	30.03	+.06	44.6	+2.7	49.6	39.6	56	35	2.19	−0.93	0.0
Barkerville, B. C.	4,180	25.47	29.82	−.06	28.4	+2.3	36.4	20.5	47	1	2.88	+0.99	26.6
Estevan Point, B. C.	20				41.5		47.4	35.6	52	28	8.77		T.
Prince Rupert, B. C.	170				39.2		43.8	34.7	52	27	12.21		18.6
Hamilton, Ber.	151	30.00	30.17	+.09	63.7	+1.5	69.3	58.1	76	51	2.74	−2.39	0.0

LATE REPORTS, FEBRUARY, 1929

Kingston, Ont.	285	29.77	30.11	+.07	17.8	0.0	25.9	9.8	42	−10	1.13	−1.41	10.1
White River, Ont.	1,244	28.65	30.05	+.03	−1.3	−1.5	14.0	−16.6	35	−46	0.96	−0.56	9.6
Winnipeg, Man.	760	29.26	30.16	+.06	−0.3	+1.3	8.8	−9.5	30	−26	0.28	−0.70	2.8
Medicine Hat, Alb.	2,144	27.68	30.06	+.01	7.8	−3.4	18.6	−3.0	39	−32	1.40	+0.73	13.0
Calgary, Alb.	3,428	26.36	30.11	+.12	13.2	−0.3	25.3	1.2	46	−30	0.55	−0.08	5.5
Banff, Alb.	4,521	25.30	30.11	+.13	12.0	−7.2	24.0	0.0	37	−27	0.74	−0.18	7.4
Edmonton, Alb.	2,150	27.66	30.08	+.06	8.6	+0.3	18.2	−0.9	45	−39	1.05	+0.38	10.5
Kamloops, B. C.	1,262	28.91	30.28	+.32	15.4	−12.9	22.6	8.2	45	−13	0.06	−0.73	0.5
Barkerville, B. C.	4,180	25.64	30.10	+.19	14.9	−4.0	24.3	5.5	36	−17	2.55	−0.51	25.5
Estevan Point, B. C.	20				36.5		44.4	28.6	48	15	2.02		0.0
Prince Rupert, B. C.	170				34.7		39.6	29.9	46	11	4.97		6.7
Hamilton, Ber.	151	30.00	30.17	+.06	62.8	+1.3	68.8	56.8	74	44	2.42	−2.02	0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, March, 1929

Chart I. Departure (°F.) of the Mean Temperature from the Normal, March, 1929

Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.

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Chart II. Tracks of Centers of Anticyclones, March, 1929. (Inset) **Departure of Monthly Mean Pressure from Normal**

(Plotted by Arthur J. Haidle)

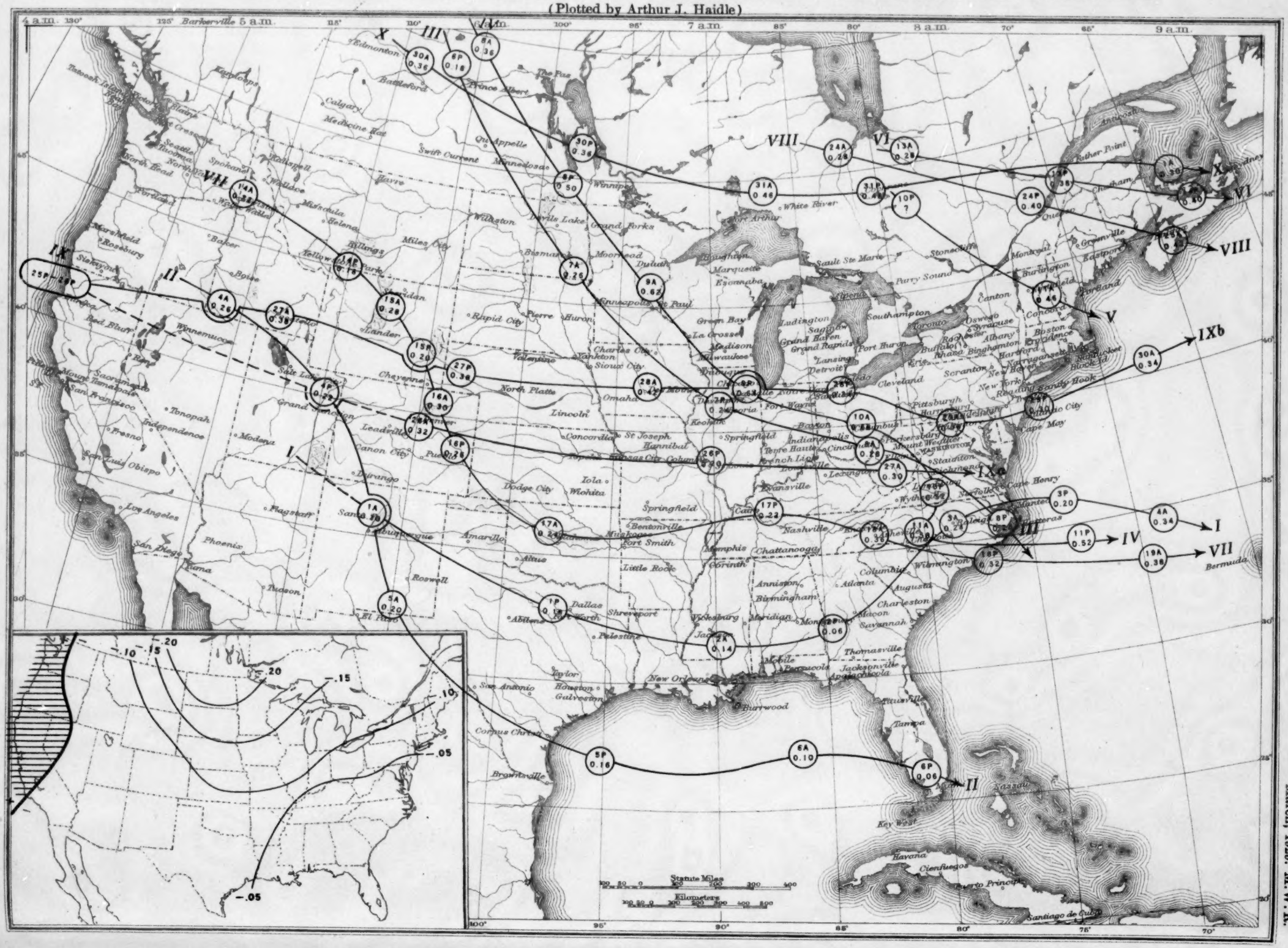


Chart III. Tracks of Centers of Cyclones, March, 1929. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by Arthur J. Haidle)

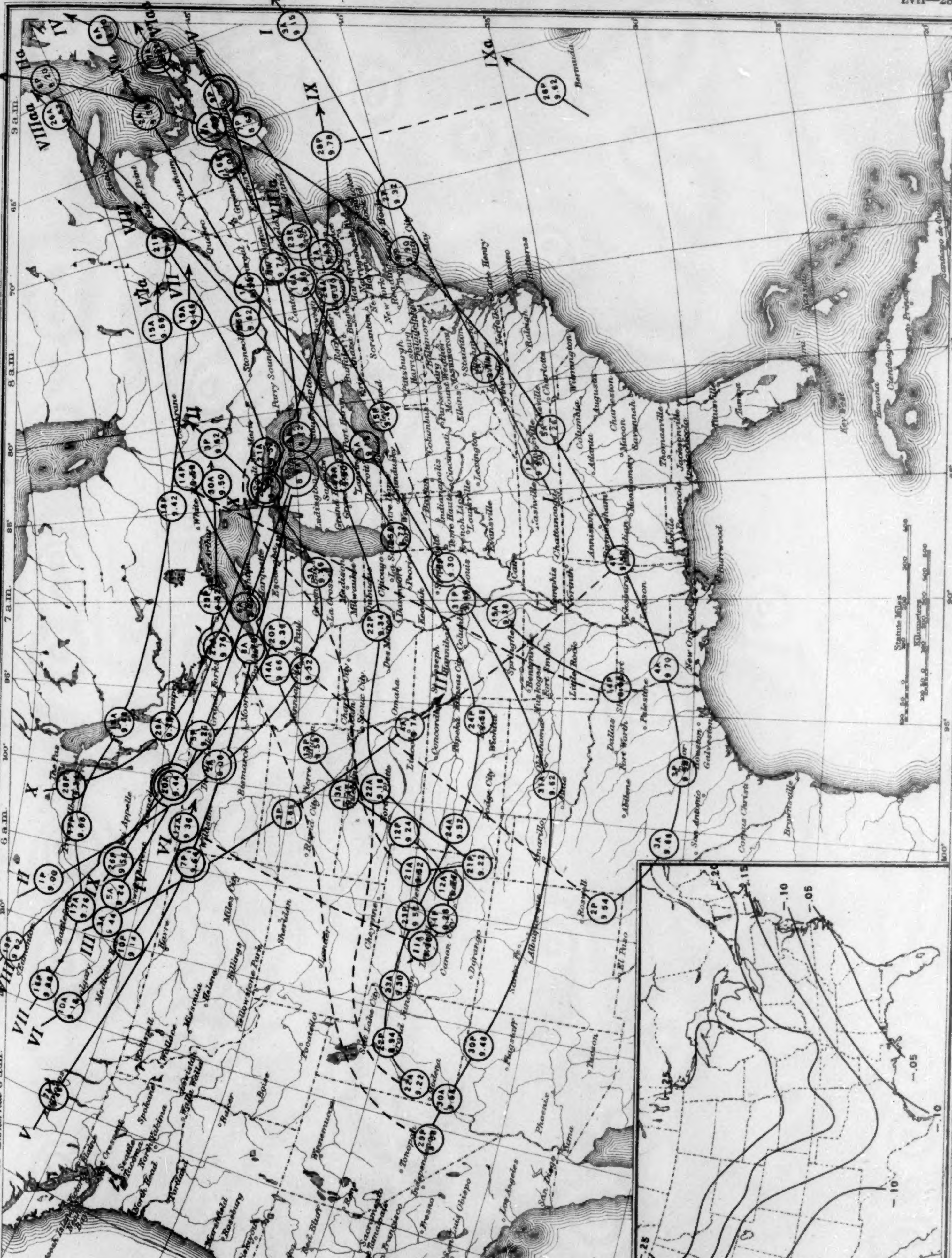
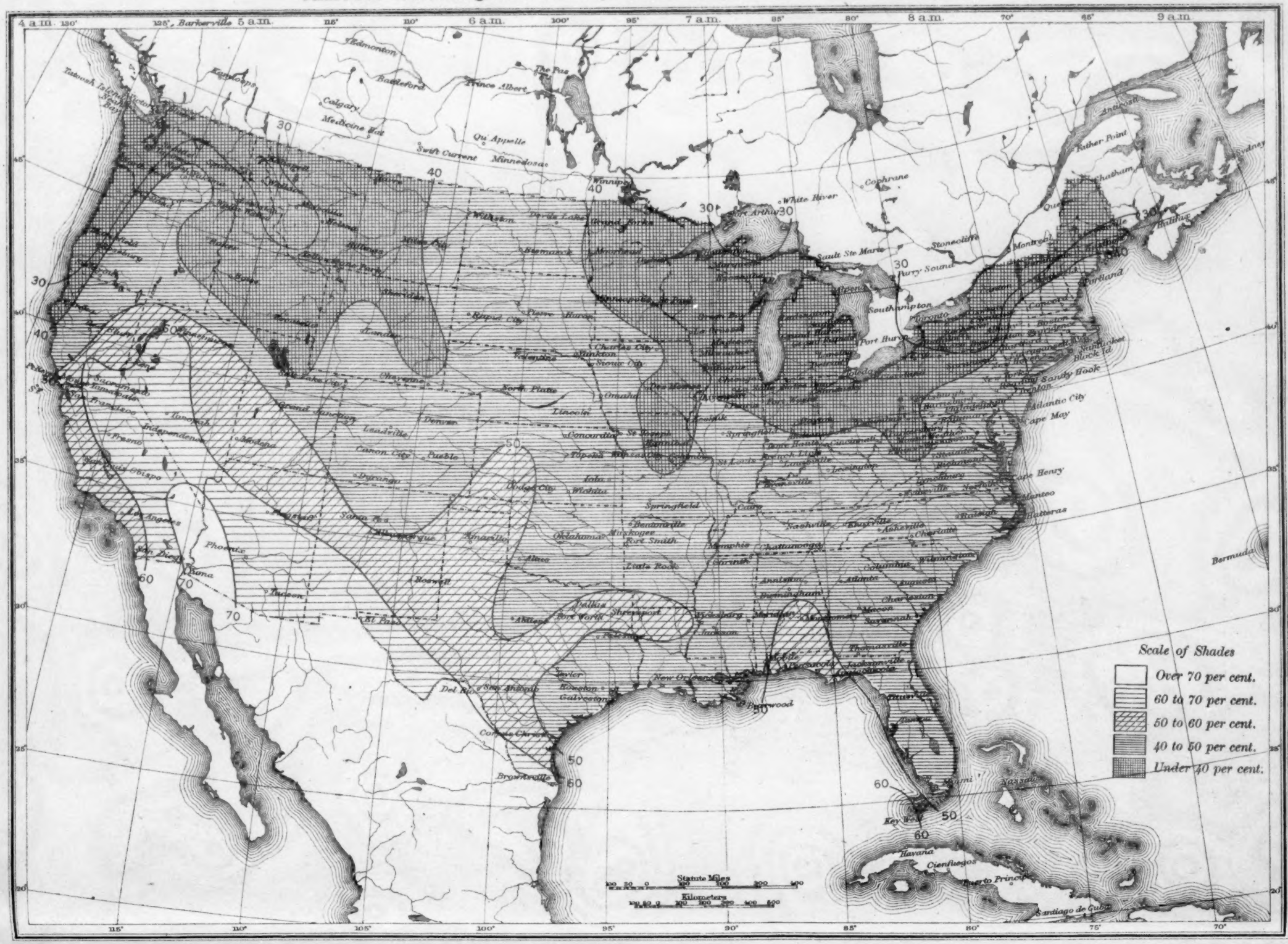


Chart III. Tracks of Centers of Cyclones, March, 1929. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by Arthur J. Haidle)

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, March, 1929



March, 1929. M. W. R.

Chart V. Total Precipitation, Inches, March, 1929. (Inset) Departure of Precipitation from Normal

Chart V. Total Precipitation, Inches, March, 1929. (Inset) Departure of Precipitation from Normal

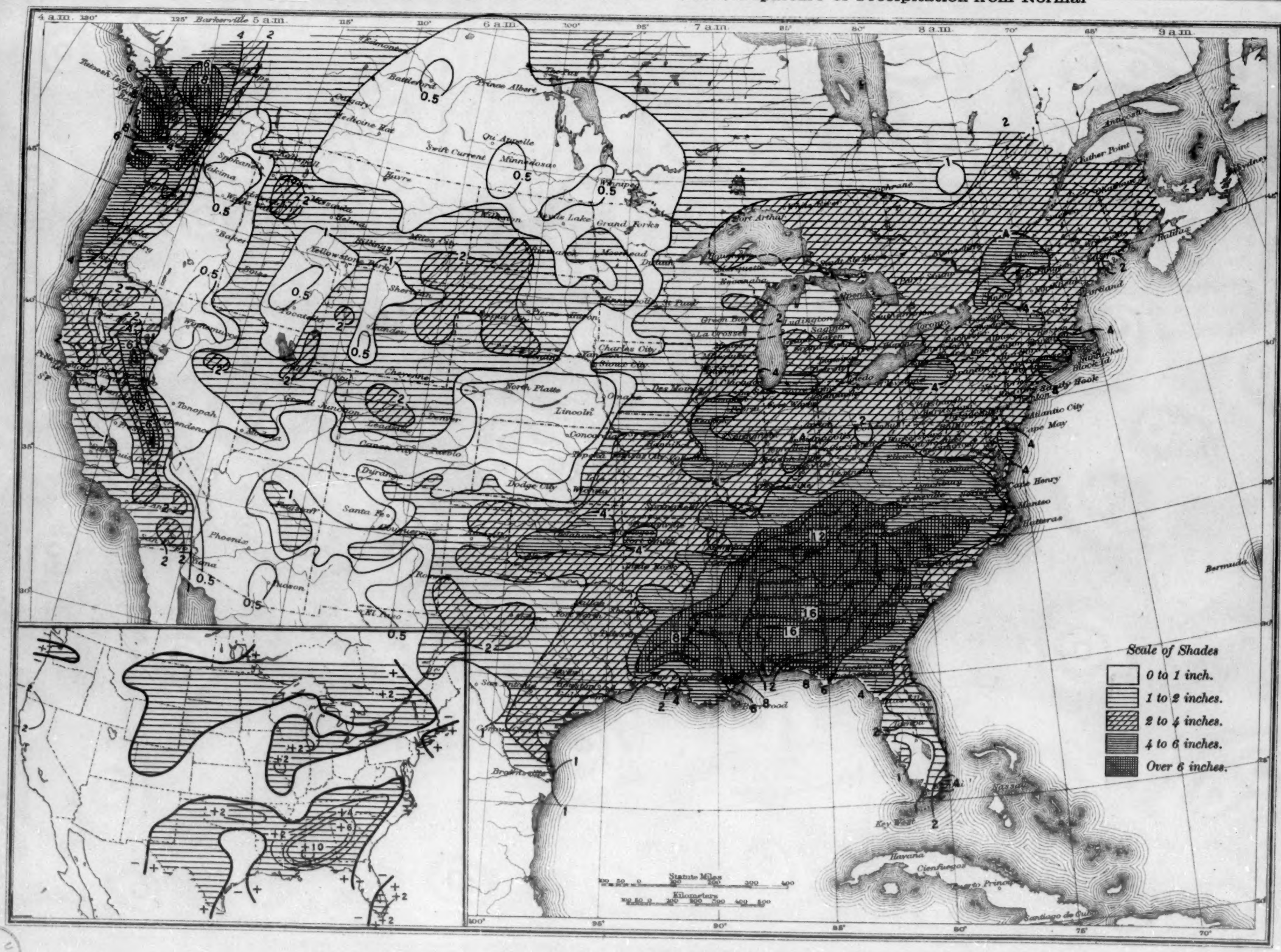


Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, March, 1929

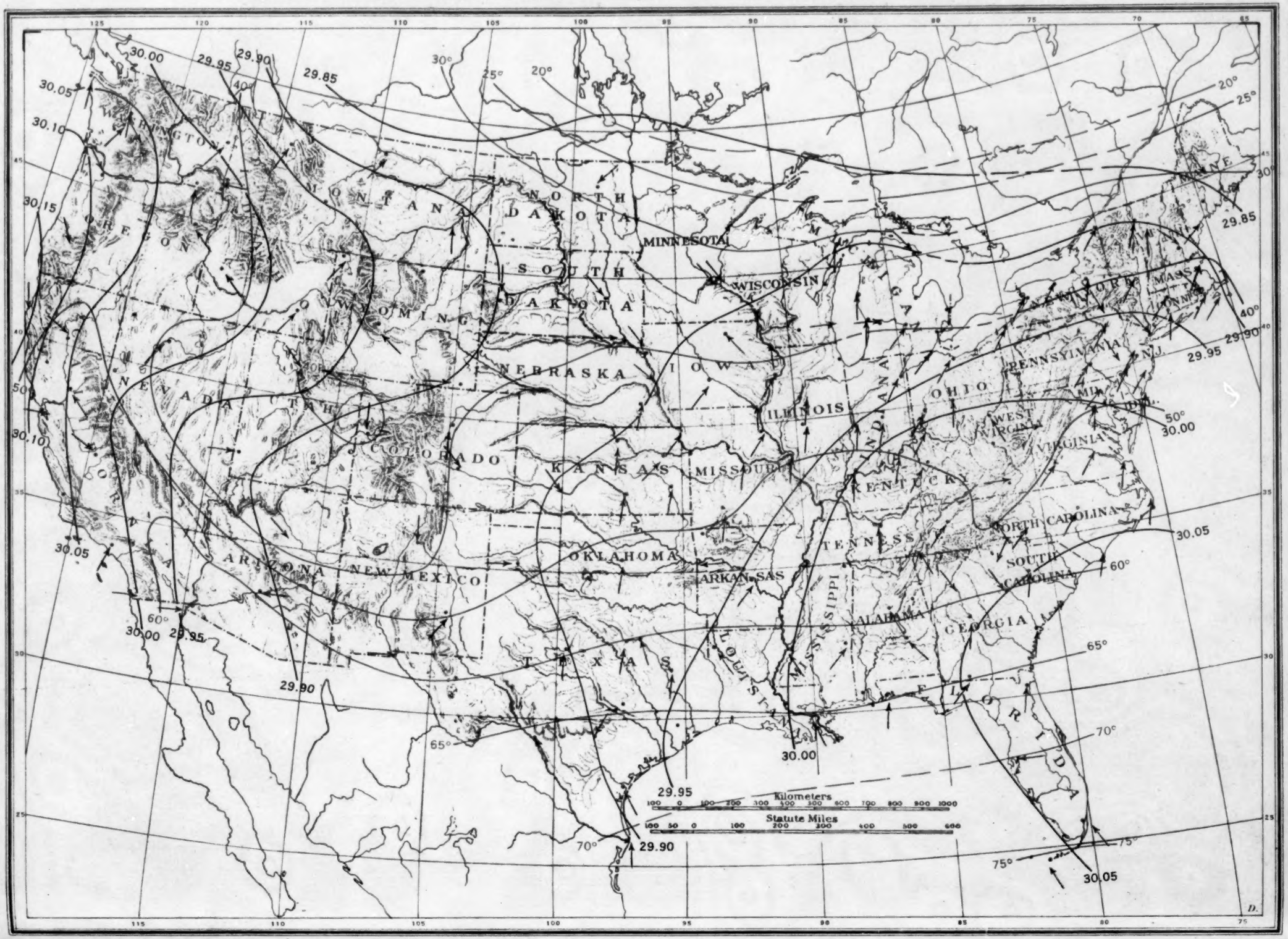


Chart VII. Total Snowfall, Inches, March, 1929. (Inset) Depth of Snow on Ground at end of Month

Chart VII. Total Snowfall, Inches, March, 1929. (Inset) Depth of Snow on Ground at end of Month

Chart VIII. Weather Map of North Atlantic Ocean, March 1, 1929

Chart VIII. Weather Map of North Atlantic Ocean, March 1, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

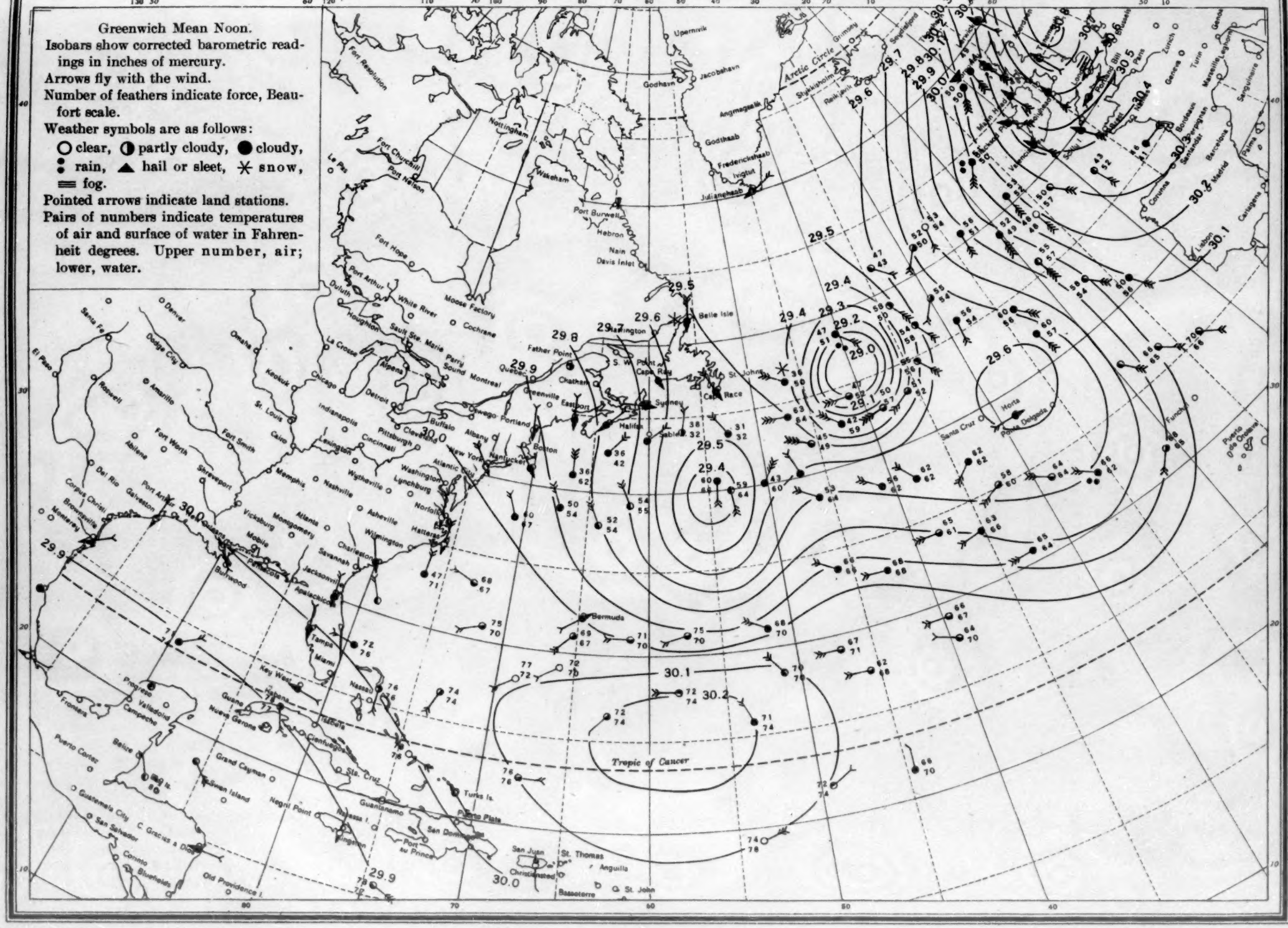


Chart IX. Weather Map of North Atlantic Ocean, March 2, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

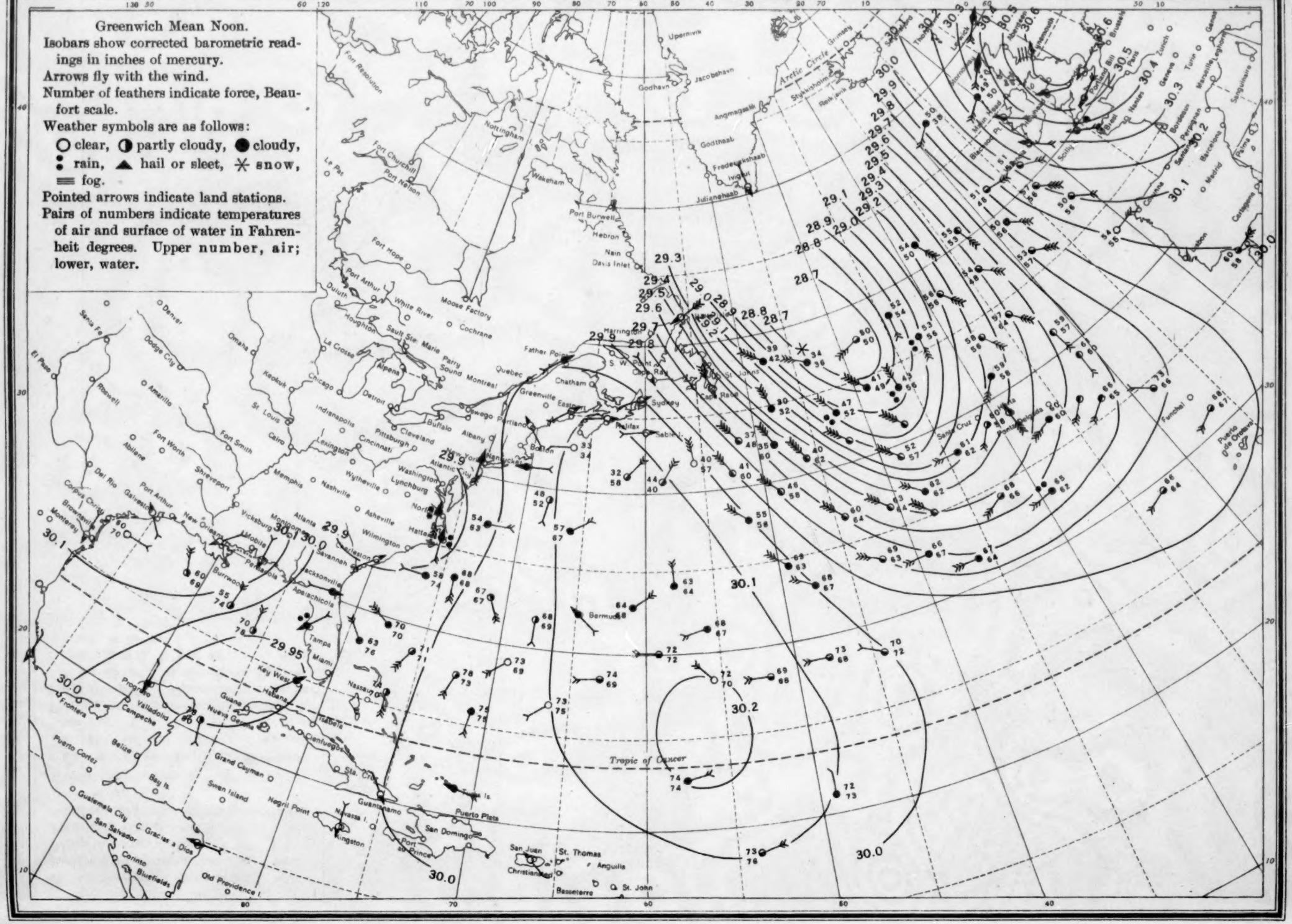


Chart X. Weather Map of North Atlantic Ocean, March 3, 1929

(Plotted by F. A. Young)

Chart X. Weather Map of North Atlantic Ocean, March 3, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

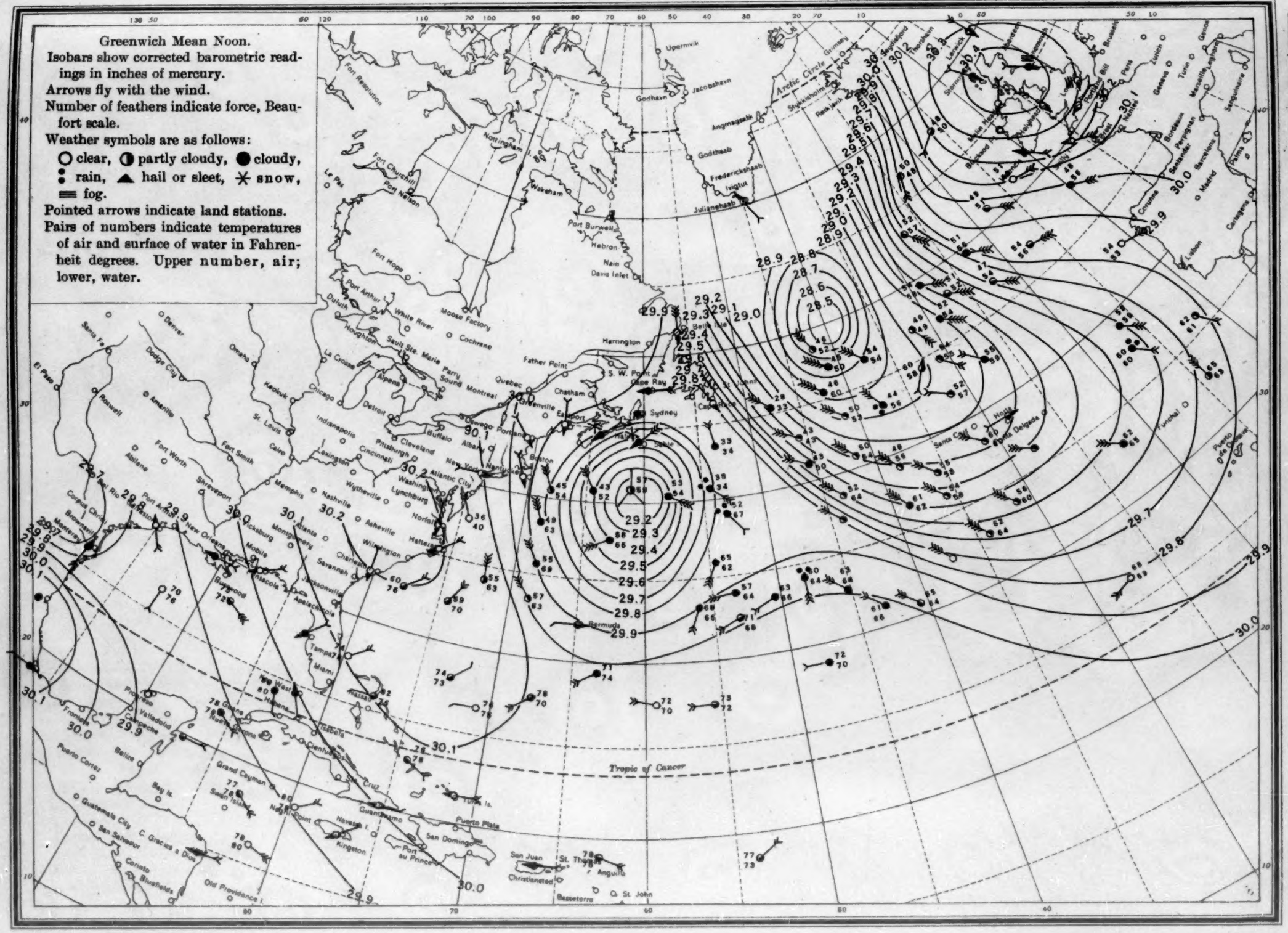


Chart XI. Weather Map of North Atlantic Ocean, March 4, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

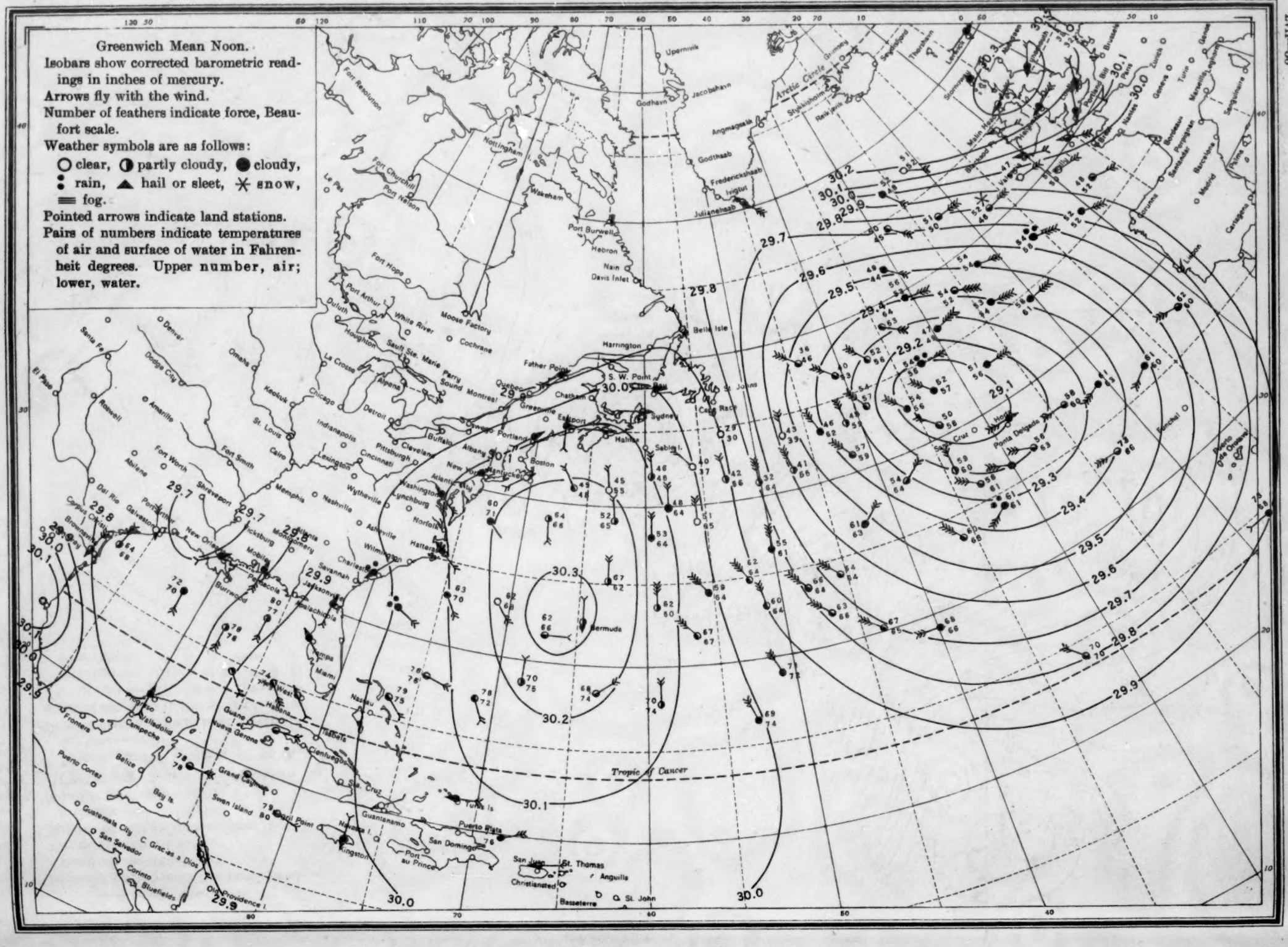


Chart XII. Weather Map of North Atlantic Ocean, March 5, 1929

(Plotted by F. A. Young)

Chart XII. Weather Map of North Atlantic Ocean, March 5, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

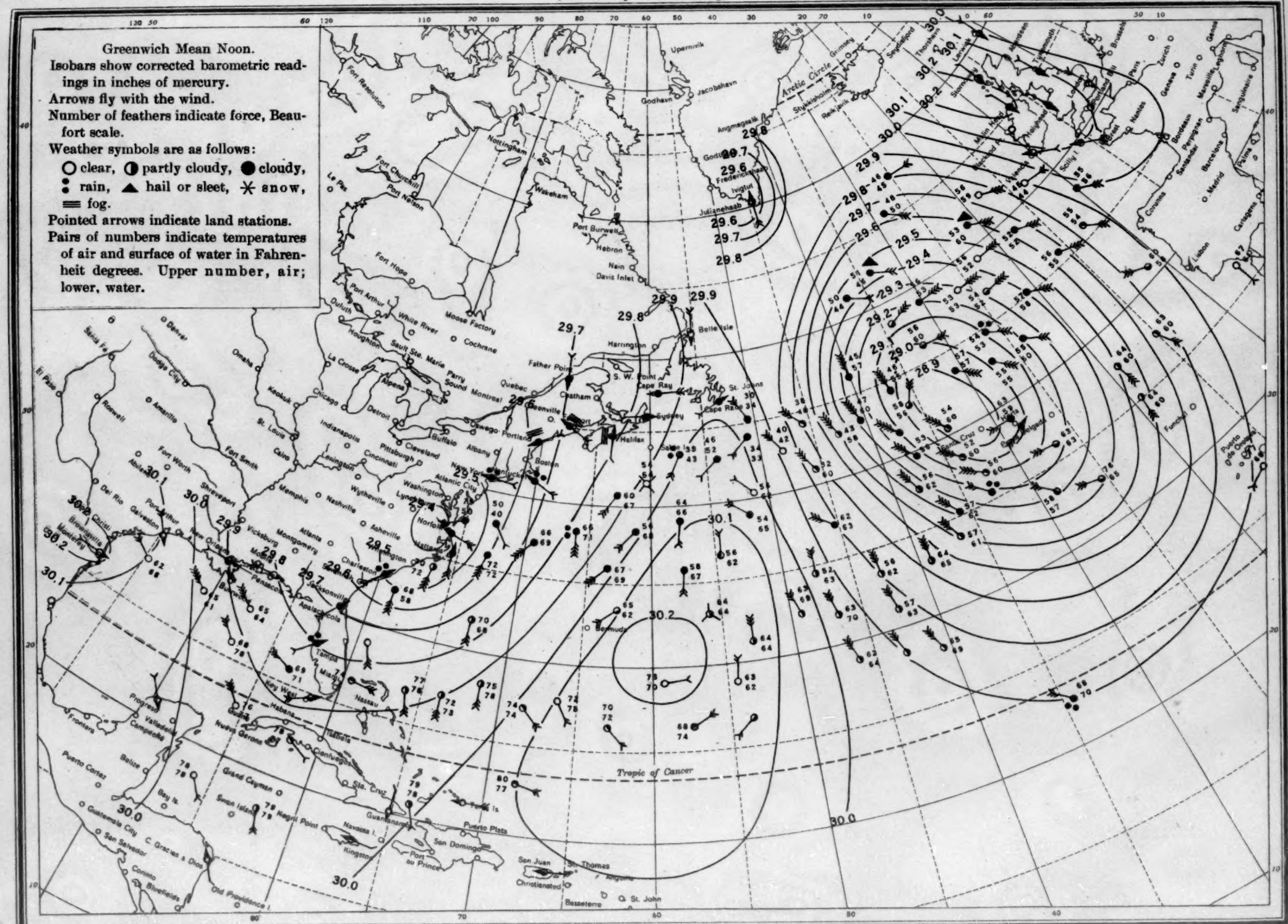
Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.



U.S. WEATHER BUREAU

Chart XIII. Weather Map of North Atlantic Ocean, March 6, 1929

(Plotted by F. A. Young)

Greenwich Mean Noon.

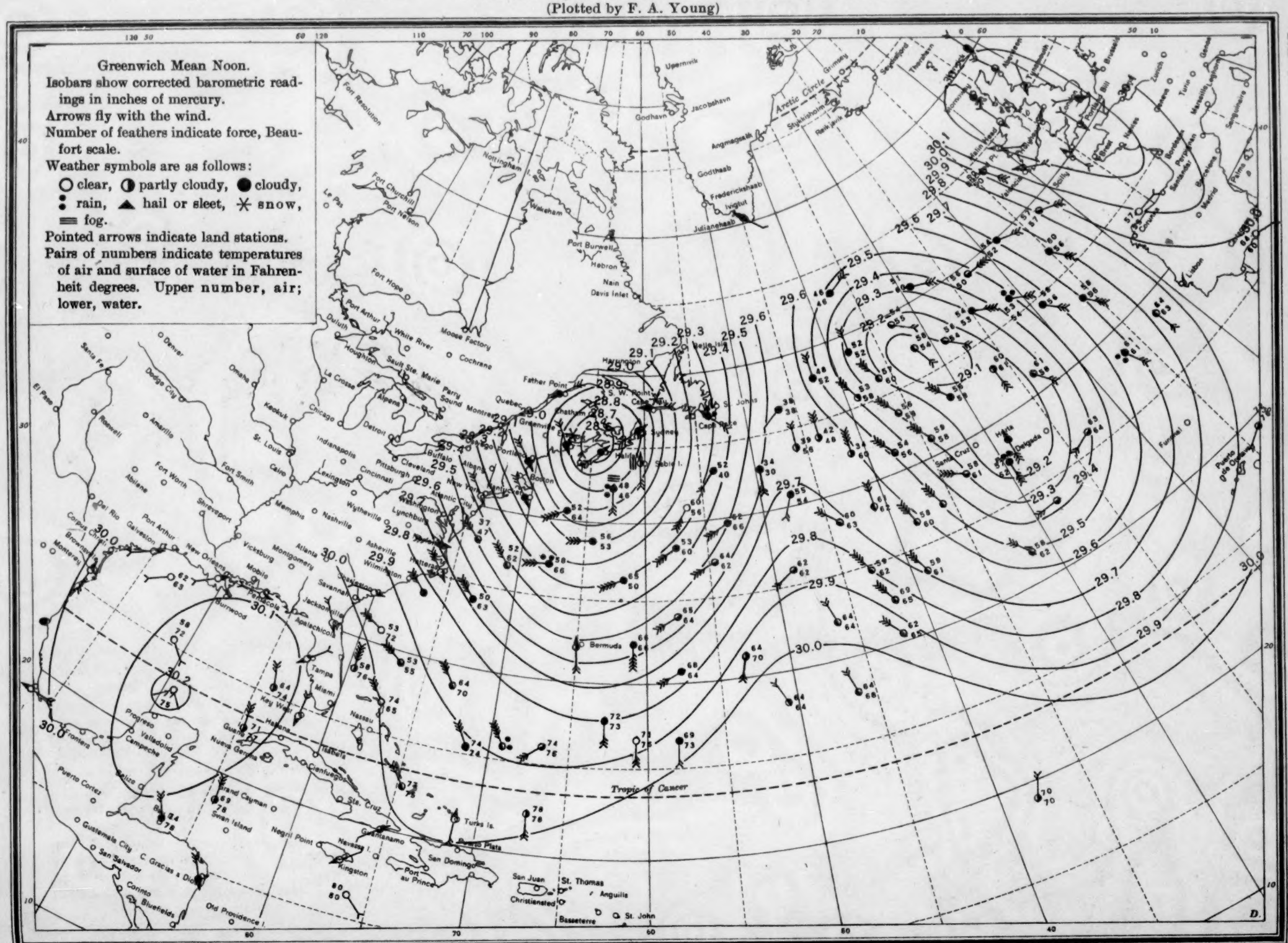
Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.